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MR. C. M. PALMER, M.P., AND THE SHIPBUILDING TRADE ON THE TYNE.

THE commercial and industrial interests of Great Britain owe very much to the Tyne. It was on the banks of the coaly river that the locomotive was born, and the railway system was first developed. It was there, also, that Stephenson invented his safety lamp; that Buddle perfected the furnace ventilation of mines; that Pattinson invented and perfected his process for the desilverizing of lead; that Sir William Armstrong gave to the country one of its most valuable arms of defence; that Nicholas Wood carried out those improvements in mining engineering, with which his name is associated. There, also, it was that the manufacture of glass, alum, and soda were first commenced in this country. In brief, it may be said of the Tyne, that there is no salient aspect of our industrial greatness with which it is not to some extent associated, and which it has not done something to promote.

The Tyne has a curious and interesting history. If we go back for only a hundred years, we shall find that its trade was of the most restricted character, being almost entirely limited to the shipment of coals from the Durham and Northumberland coal fields. Its navigable capacity was very imperfect. Full of shoals and rocks, and without any uniform depth, it was only adapted for carrying vessels of ten to twelve feet draught. But out of the shipment of coal other industrial relations arose. The iron trade became established on both sides of the river. Chemical and other works were erected on her banks. A larger class of vessels with a deeper draught came into her ports. It became necessary to make provision for the reception and accommodation of a larger shipping trade. With this view the Tyne Conservancy Commission was established. According to a plan laid down by the late Mr. Rennie, in 1813, river walls were constructed between what is known as the Bill Point, and Jarrow Slake. In 1857, the Tyne Commissioners constructed the Northumberland Dock, with an area of 50 acres. In 1859, the North Eastern Railway Company constructed the Tyne Dock with an equally large area. Steps were also taken for the deepening of the river, and between 1838 and 1863 dredging machines removed 7,884,829 tons from the bed of the river. With the improvement of the river, its trade became enormously increased. The value of the exports rose from £1,344,946 in 1866, to £3,055,357 in 1872. The quantity of shipping belonging to the Tyne is now larger than that owned by any other river in the kingdom, with the exception of the Thames, the Mersey, and the Clyde; and no river enjoys to a fuller extent all the elements of industrial and commercial progress. From the sea to a considerable distance above Newcastle, it is one spacious harbour, being nearly 20 miles long, and varying in width from 400 to 1400 feet.

With its manifold advantages for carrying on a large and lucrative trade in iron shipbuilding, it may appear somewhat wonderful that the Tyne has not taken up a more distinguished position in relation to that industry. On every side there are coalfields of infinite extent and enormous productive capacity, the united counties of Durham and Northumberland furnishing not less than 30,000,000 tons of the 120,000,000 tons of coal annually raised in the United Kindom. Within easy distance, the Cleveland hills contain the cheapest and most abundant resources of iron ore to be met with from Land's End to John o' Groat's; and in the Cleveland district the production of both crude and manufactured iron is larger than in any other district in the world. The imports of timber into the Tyne are enormous in bulk and value. And yet, in spite of all these, and collateral advantages of scarcely less moment, the shipbuilding trade on the Tyne has made little progress relatively to its development on the Wear and the Clyde.

Defoe, writing of the Tyne in 1727, says, "they build ships here to perfection—I mean as to strength and firmness and to

bear the sea." But until the year 1840, only wooden vessels were constructed on the river, and the aggregate annual tonnage launched was inconsiderable; the vessels being chiefly small craft of the collier class, intended for coasting purposes.

In March, 1840, the "John Garrow," of Liverpool, 800 tons burthen, arrived at Shields. This is said to have been the first iron vessel seen in the Tyne, and its appearance was a source of infinite wonder to the canny Tynesiders. Shortly afterwards a shipbuilding firm at Walker undertook the construction of the "Prince Albert," and this, the first iron steamer built on the Tyne, was launched on the 23rd September, 1842. Since then, iron has gradually superseded wood among the shipbuilders of the Tyne, as among shipbuilders elsewhere, until now, the number of vessels built of the latter material is hardly worth reckoning.

From the interesting statistical work annually issued by Mr. W. W. Watson, the city chamberlain of Glasgow, it appears that the tonnage launched on the Tyne, during the seven years ending 1869, is as follows :—

Year.	Tonnage launched.
1863	29,714
1864	29,968
1865	33,087
1866	31,453
1867	16,224
1868	25,694
1869	33,158

In the year 1863 it was stated before the meeting of the British Association, held in Newcastle, that the tonnage launched on the Tyne in the preceding year, 1862, was estimated at 32,175 tons, so that there has been no advance worth speaking of in regard to the amount of tonnage launched on that river during the period under review. The above figures compare most unfavourably with those relating to the Wear, which is only about twelve miles distant from the Tyne, and is in no way better adapted for the prosecution of this industry. The following table, compiled from official sources, shows the progress of the shipbuilding trade on the Wear since 1859 :—

Year.	No.	Tons.	Average Tons.
1859	100	37,184	371
1860	112	40,201	358
1861	126	46,778	371
1862	160	56,921	355
1863	171	70,040	410
1864	153	71,987	470
1865	172	73,134	425
1866	145	62,719	432
1867	128	52,249	408
1868	138	70,302	509½
1869	122	72,420	585½
1870	103	70,084	680½
1871	97	81,903	844½
1872	122	136,507	1,155

In contrasting the Tyne with the Clyde we find an equally startling disparity; for the amount of tonnage launched on the latter river increased from 124,000 tons in 1863 to 230,000 tons in 1873, being an increase equal to more than double the total tonnage launched during the latter year on the Tyne.

Whatever may be the value and prominence of the position attained by the Tyne in marine architecture, it is mainly due to the administrative and constructive ability of Mr. Charles Mark Palmer; and a history of the shipbuilding trade of that river during the last twenty years, is really a history of his life. No one ever thinks of Tyne shipbuilding in connection with any other name than that of Palmer's. There are other ship-builders on the Tyne, but none that have achieved such a reputation, or accomplished such results in relation to her marine architecture; and inasmuch as everything of historic interest in the annals of this industry is associated with the name that heads this paper, it now behoves us to drop the historical and take up the biographical form of narrative.

Mr. Charles Mark Palmer was born at South Shields, one of the Tyne ports, in 1822, so that he is now in the fifty-second year of his age. In his early life Mr. Palmer's father was the captain of a whaler—a calling which he afterwards abandoned in favour of ship-owning and controlling a large export trade on the Tyne. The sire could thus afford to bestow upon the son a good education, which was commenced at Bruce's academy in Newcastle, and completed in the South of France. Returning home again, young Palmer joined the business of his father, then carried on under the style of Palmer, Beckwith, & Co. At the early age of twenty-three he displayed his remarkable business aptitude and discrimination by associating himself with Mr. John Bowes, of Streatlam Castle, Sir William Hutt, late M. P. for Gateshead, and the late Mr. Nicholas Wood, in establishing coke works at Marley Hill. Soon afterwards he became part proprietor of the Marley Hill Colliery. In his business relations, therefore, Mr. Palmer early became associated with three men whose names are at this day household words in the North of England, who possessed all the enterprise, energy, and skill necessary to success in business, and to whom, no doubt, it is greatly due that in after years Mr. Palmer was enabled to achieve such remarkable success.

Mr. Palmer was not trained as a ship-builder. He became connected with that industry more by accident than by design, and in a rather remarkable manner. As a colliery owner he felt that a new kind and class of vessel was necessary for the carrying trade between the Tyne and the Thames, in order to enable the northern coal-masters to compete successfully with their rivals in the south, who had the advantage of railway communication at a cheaper rate of freight. In 1852, therefore, he built the first screw collier that ever plied on the Tyne. He named the vessel the "John Bowes," after one of his partners and best friends. She was built to carry 650 tons, and to steam about nine miles an hour. On her first voyage the "John Bowes" was laden with a full cargo in four hours. In forty-eight hours she was in the Thames. Twenty-four hours more sufficed for the discharge of her cargo, and in forty-eight hours more she was again in the Tyne, so that in five days she performed successfully an amount of work which Mr. Palmer has himself said, "would have taken two average sized sailing colliers upwards of a month to accomplish." In spite, however, of the unequivocal success of the "John Bowes," Mr. Palmer's screw collier was long regarded as an impracticable and expensive—and impracticable only because expensive—venture. Even at that time of day it required £10,000 to construct a vessel of this class, and as money was then much more valuable and less plentiful than it has since become, shippers and colliery owners hesitated before incurring such a large outlay when, as they thought, the ordinary sailing collier could perform the work equally well—although with much less expedition—and at less than one-tenth of the cost. All such objections, however, were overcome by the results, which fully vindicated Mr. Palmer's views. The old sailing collier gradually went to the wall, and its more expeditious rival came to be generally preferred. Mr. Palmer furnished to the British Association, in 1863, the following statement of the cargoes of coal imported into London by screw steamers from July 31, 1852 (the date of entry of the first screw steamer, the "John Bowes"), to June 30, 1863 :—

Year.	Cargoes.	Tons.
1852	17 making	9,483
1853	123 „	69,934
1854	345 „	199,974
1855 (Crimean war)	174 „	85,584
1856	413 „	238,597
1857	977 „	547,099
1858	1,127 „	599,527
1859 (Italian war)	899 „	544,614
1860	1,069 „	672,476
1861	1,299 „	851,991
1862	1,427 „	929,825
1863 half year ending June	714 „	463,609
		5,212,713

During the period included in the above table the screw collier was greatly improved and enlarged, some vessels of this class having been built with a capacity of 1,500 tons. The "James Dixon" made as many as 57 voyages to London (from the Tyne) in one year, delivering 62,842 tons of coal, with a crew of only 21 hands; and to accomplish an equal amount of work with sailing colliers, would have required 16 ships, and 144 hands to man them.

It was doubtless a perception of the probable requirements of the northern coal trade, in the construction of steam colliers, that led Mr. Palmer to undertake the erection of iron-shipbuilding works at Jarrow, a place that has acquired an almost classical interest from its association with the name of the Venerable Bede. Situated on the Durham side of the river Tyne, Jarrow was, in 1852, a place of only some 600 or 700 inhabitants. At the present time its population is not less than 25,000; and this extraordinary growth is mainly due to the establishment of Palmer's iron-shipbuilding works. In commencing that venture, Mr. C. M. Palmer was joined by his brother George, who shortly afterwards retired, and his place was taken by Mr. James Allport, now general manager of the Midland Railway. The first important Admiralty contract with which the firm was entrusted was the construction of the "Terror," a large iron-clad floating battery, designed to operate against Cronstadt during the Russian war. Although a vessel of 2,000 tons burthen, 250 horse-power, and carrying 26 sixty-eight-pounder guns, the "Terror" was built in three and a-half months; and Mr. Palmer has declared that "she would have been completed in three

months, had not the declaration of peace slackened the energies of our men, which up to that time had been so nobly maintained by their patriotic feelings."

It is interesting to remark that it was in the construction of the "Terror" that rolled armour plates were used for the first time. The engagements of the Admiralty, and the large extent to which foreign nations were then adding to their naval power, caused a demand for forged armour plates to supply which the forges of the country were utterly inadequate. Hence, although they were opposed by the Admiralty, the Messrs. Palmer were compelled to have recourse to rolled armour plates; and, to overcome the prejudices of the Admiralty authorities, a trial of this new description of plates was resolved upon. The results of this trial we will let Mr. Palmer communicate in his own words. "We built," he says, a target, nine feet square, on a plan which we thought might be advantageously adopted for large vessels of war, and on the cellular principle. The cells were filled with compressed cotton, which we had found by experience to be very effectual in stopping shot. On this target was a thin teak backing, and on the teak were bolted, one hammered, and two rolled plates. The target was bolted on to the side of an old wooden frigate at Portsmouth, under the direction of Capt. Hewlett. The first shot fired at it missed the target, went through both sides of the frigate, and to my great astonishment skimmed over the surface of the water for nearly a mile. The firing showed that whilst the hammered plate split and cracked to pieces, the rolled plates were not broken, but only indented, and were superior to the hammered plate in every respect. Unfortunately the target was not firmly bolted to the vessel, and it sprung at each shot, so that the bolts which held the armour plates were broken and they fell into the sea. A shot was then fired to test the resisting power of the compressed cotton, and it appeared to answer so well that Capt. Hewlett advised a series of experiments to be tried. The Admiralty were willing, but required us to provide the target at our own expense. Having already spent upwards of £1,000 for the good of the country we declined the proposal; nevertheless we had proved to the Admiralty this important fact, that the rolled plates were superior to the forged, and they have since been universally adopted. We claim, therefore, for this district (Tyneside) the honour of being the first to prove the strength and ability of rolled armour plates, since known and spoken of in Parliament as "Palmer's Rolled Plates."

The next important contract which Mr. Palmer undertook for the Admiralty was the "Defence," an iron-plated frigate of 3,688 tons; and shortly afterwards he built the "Jumna," a troop ship of 4,173 tons, also for the British Government. Another war vessel of a different class subsequently constructed at the Jarrow Works, was the "Cerberus," an iron-plated monitor of 2,107 tons. This vessel was plated with 9 in. armour plates for a depth of 7 ft. 4 in.; the turret being cased with 10 in. plate. She had only one hatchway—a solid tube of iron, and was propelled with twin screws, and steered with a hanging rudder. The last vessels of war built at Jarrow were the "Triumph" and "Swiftsure," steam rams carrying powerful batteries of guns of large calibre, and containing several new features, previously unattempted in marine architecture.

Mr. Palmer is as intimately identified with the formation of the National Steam Navigation Company as Mr. Robert Napier of Glasgow has been associated with the establishment of the Cunard line; and it is not too much to say that the former line is a powerful and worthy rival of the latter. It was shortly after the outbreak of hostilities between the Northern and the Southern States of the great North American Republic, that a number of gentlemen formed a company with the view of carrying on the trade which was likely to spring up between the old country and the Confederated States when peace should again be restored. In pursuance of this idea they started a joint-stock company for the purpose of running a regular periodical line of first-class steamers between Liverpool and New Orleans, under the designation of the British and American Steamship Company. The project was generally admitted to be extremely feasible, and met, as it deserved, with a large amount of public favour. But the anxiously expected peace between the Northern and the Southern States did not arrive so soon as had been anticipated, and hence the proposed trade with New Orleans could not be carried on. But Mr. C. M. Palmer and the gentlemen who concerted with him in this enterprise were not disposed to abandon it altogether; and it was ultimately determined to seek a more extended sphere of operations. In October, 1863, therefore, the original co-partnership was merged in that of the National Steam Navigation Company. The Messrs. Fernie, of Liverpool, and Mr. Edward Lawrence, formerly mayor of that town, were connected with Mr. Palmer in this important undertaking.

It was one of the first intentions of the founders of the National Line to establish a connection between Liverpool and other foreign ports than those of the North American continent. The project was a bold and hazardous one, for most of the transatlantic lines with which the National proposed to come into competition were subsidized, either by the British or by the American Government. But it was wisely resolved that the steamers of the National should not seek to compete in speed with those of other lines, and in this way the expense of working the line was materially lessened, the effort to obtain an extra knot per hour adding very materially to the cost of fuel in long voyages. Indeed, it was pointed out to the American Congress, with reference to the Collins line of American steamers, "that the saving of a single day or a day and a half on the voyage to Liverpool, cost nearly half a million of dollars annually," and yet the extra knot per hour is the sole distinguishing difference between the mail and the cargo-carrying steamers.

As Mr. Palmer had not only a large stake in the newly-projected company, but had already supplied proof of the high excellence of the work turned out of his shipbuilding works at Jarrow, he was entrusted with the construction of the first steamers of the National line. These were the "Louisiana," of 2,166 tons and 250 horse-power; the "Virginia," of 2,887 tons and 300 horse-power; the "Pennsylvania," of 2,889 tons and 300 horse-power; the "Erin," of 3,318 tons and 350 horse-power; and the "Helvetia," of 3,318 tons and 350 horse-power; thus giving to the first five steamers of the line an aggregate of 14,578 tons, and of 1,550 horse-power. Subsequently Mr. Palmer constructed for the National and other transatlantic lines the following well-known steamers:—

Name.	Tons.	Horse-power.
Georgia	2,876	300
Ontario	3,315	350
Scotland	3,698	400
England	3,307	400
Nebraska	3,336	400
Manhattan	2,869	350
Chicago	2,912	350
Minnesota	2,887	350
Colorado	2,929	350

In the carrying out of all these contracts, Mr. Palmer gave the most complete satisfaction; and it is noteworthy that the vessels built at his works have enjoyed a greater immunity from misadventure than those of almost any other line, except the Cunard. From its commencement, the National line proved a complete success. In the second year of its existence it carried about 22,000 persons across the Atlantic. A scrupulous attention to economy of fuel enables the company to work with a lower cost than almost any other line, and as there is thus a margin for a lower rate of freight than that charged by the other first-class companies, the National line enjoys a high degree of popularity. Within the last two years this company has had some of the largest steamers afloat constructed on the Clyde, and its fleet promises to become in the course of a short time one of the largest and most important connected with the port of Liverpool.

The Jarrow Shipbuilding Works.

There are several salient features of the Jarrow works which distinguish them from all other works of a similar character in this country. There is not, to begin with, another establishment in Great Britain that has everything within itself, from the raising of the coal and ironstone, and its reduction in the blast-furnace, to the complete equipment of the vessels undertaken by the firm. On the Clyde there is not a single ship-builder who does not buy in the open market all the iron, coal, and timber required for his constructive purposes; and the same remark applies to the ship-builders of the Wear, the Mersey, and the Humber. The only parallel to the Jarrow works with which we are acquainted are the works of the Société John Cockerill at Séraing, where the raw materials are raised from the bowels of the earth within the same area that includes the shipbuilding yard and engine works. This is not quite the case at Jarrow, for the ironstone is taken from Port Mulgrave, about sixty miles distant, and the coal is obtained from the Marley Hill, or some other of Mr. Palmer's collieries, situated at a considerable distance from Jarrow.

The Jarrow works cover an area of ninety-eight acres of ground, and give employment to about 5,000 hands, but the total number of hands in the employment of the company of which Mr. Palmer is the head is not less than 12,000. The works may be classified in the following order:—

I. The ironstone mines at Port Mulgrave in Cleveland.

II. The collieries in Durham, Northumberland, and Wales.

III. The blast furnace department at Jarrow, where the manufacture of pig-iron, kentledge, and rough castings is carried on.

IV. The forges and rolling mills, in which angle iron of all sizes up to 10 and 3 inches, rounds and squares to 5 inches, bulb iron up to 10 inches, merchant bars, rails, and plates, are produced.

V. The engine works at Jarrow, where marine and land engines, land and marine boilers, forgings and castings, are manufactured.

VI. The iron shipyard at Jarrow, with a frontage to the Tyne which admits of half-a-dozen large-sized vessels being on the stocks at the same time.

VII. The bridge-building yard at Howdon.

The shipbuilding yard was the first of many constructive departments now in operation at Jarrow. It was commenced in 1852. Four years later Mr. Palmer acquired the ironstone mines at Port Mulgrave in Cleveland, and commenced at Jarrow, in close proximity to his shipbuilding yard, the erection of blast furnaces. In 1859, the forges and rolling mills were added, making the Jarrow works complete.

When Mr. Palmer first planted his foot in the Cleveland district, Port Mulgrave was a *terra incognita*, almost inaccessible by sea, and altogether inaccessible by land. Having leased from Lord Normanby a royalty of 1,000 acres, he commenced to provide facilities for its removal to Jarrow; and to accomplish this he had to construct a new harbour at a cost of £40,000. In the complete absence of railway communication, it was necessary to ship all the ironstone; but this was done with very little cost by employing the vessels that carried coal from Mr. Palmer's collieries to London in taking up cargoes of ironstone on their return voyage. Within six years of the Port Mulgrave mines being opened out, they yielded 2,500 tons per week. The blast furnaces, four in number, are each 65 ft. in height, 19 ft. diameter at the boshes, and 9 ft. at the hearth. Their united production when in full work is about 1,600 tons per week. About two-thirds of this quantity is passed on to the other departments of the Jarrow works, and subsequently manufactured into forgings, castings, plates, rails, and other qualities and kinds of finished iron. Along with the native ironstone of Cleveland a mixture of Cumberland or Spanish hematite is used in the blast furnaces, in order to impart to the iron greater tensile strength and purity. There is no marked peculiarity about the blast furnace arrangements. The blast is heated in fifteen stoves, fitted for the most part with double ∩ pipes, and enters the furnace at a temperature of 900 to 1000 deg. The raw materials are raised from the wharf in the river to the level of the Pontop Railway by an inclined plane, actuated by an engine with two 12-inch horizontal cylinders and 2 ft. stroke; and they are raised to the top of the furnace by another inclined plane rising at an angle of 45°. Near to the blast furnaces there are 12 kilns for calcining the ironstone; a process which the Cleveland ore requires to undergo, in order to drive off all its volatile ingredients. The coke is conveyed to the works by the Pontop and Jarrow Railway. It is discharged into a huge hopper, containing when full about 1000 tons. The coke barrows are filled underneath from openings which are closed by sluices, without manual labour. The whole arrangement of blast furnace department has been designed with a special eye to economy, and although not now the most perfect in the north of England, it was equal, if not superior to anything existing in its day.

From the blast furnaces, the crude iron is passed on to the forges and rolling mills, where the make of puddled bars is about 1,000 tons per week, exclusive of hammered scrap iron. The waste heat from the puddling furnaces is utilized in the heating of the boilers—four furnaces being equal to supplying ample heat to one boiler. There are two forge engines—one with a 36 in. horizontal cylinder and a 4 ft. stroke, and the other with a 36 in. cylinder and a 5 ft. stroke. Both engines run at the rate of 45 strokes per minute, and to each a train and 4 pairs of 22 in. puddling rolls is attached. There are 70 common puddling furnaces. In the rolling mills, which are proximate to the forge, there are two plate mills and ten mill furnaces, producing about 460 tons of plates per week. The rolling mills are four in number and are erected in a line, and two of them are used exclusively for rolling ship- and boiler-plates. Each plate mill has two pairs of 22 in. rolls, on the reversing principle. They perform 34 revolutions per minute, and the reversing is effected by means of a clutch and crabs. The third is a bar-mill, with a 24 in. horizontal cylinder and two pairs of rolls driven at the rate of 110 revolutions per minute. The average production of this mill is 120 tons per week. The fourth mill is used for rolling plates, bars, or rails, as occasion may require. It has four pair of rolls, driven by an engine with two 30 in. horizontal cylinders and 4 ft. stroke, at the rate of 38 revolutions per minute, the average weekly production being 300 tons per week. The machinery attached to the rolling mills, comprising punching and straightening presses, circular saws, and shears, is of the most efficient and powerful kind.

It is not necessary to follow the Jarrow works through their minor ramifications, including as they do all kinds of artizans and mechanics, whose services are in any way called into requisition in connection with the building or equipment of iron ships. Here are not only to be found all manner of workers in iron, but also artificers in wood, in cotton and woollen fabrics, in stone, and in every material, raw and manufactured, that can be made available for constructive purposes. Joiners, carpenters, plumbers, glaziers, painters, upholsterers, sail-makers, mast-makers, and spar-makers, do not exhaust the list. Works are erected on the spot for supplying the different shops with gas, their capacity being equal to the manufacture of 2,500,000 cubic ft. per month. From the commencement of the Jarrow works in 1852 to the end of the year 1868, there had been launched 239 vessels with an aggregate burthen of 205,419 tons, while the engines built in the same period represented 27,399 horse-power. If we assume that the average value of the ships built at Jarrow over this period is £20 per ton, we shall find, after multiplying 205,419 tons by 20 that the value of the vessels launched at Jarrow during these sixteen years was considerably over four millions sterling! But since 1868, the tonnage launched at Jarrow has rather increased than diminished in annual extent and value, averaging fully 20,000 tons per annum; so that if we add another 100,000 to the above tonnage we shall find that more than 300,000 tons have been launched at Jarrow up to the present time, and the enhanced cost of iron shipbuilding during the last three years will bring the money value of this product up to the colossal sum of seven millions sterling!

The National is not the only important line of steamers that Mr. Palmer has assisted in organizing. The Guion line of transatlantic steamers, which was essentially an American undertaking, owes much of its success to Mr. Palmer, who built a number of the company's steamers. In 1861, the Italian Government contracted with Mr. Palmer to build and work a line of steamers to run between Italy and Egypt; first between Ancona and Alexandria, afterwards between Brindisi and Alexandria. This line carried an express Indian Mail, and so far economized time over Marseilles that the English Government was at last compelled to adopt that line; it was taken up by the Peninsular and Oriental Company, and eventually they took over the contract, and Mr. Palmer retired from the line; to him therefore is due the honour of having inaugurated and established this new route to India. Three years later, he negotiated the union of several shipping firms on the Tyne, which ran, weekly or twice a week, vessels from the river to continental ports. That amalgamation is now and has since been known by the name of the Tyne Steam Shipping Company (Limited), and it is undoubtedly one of the most important and prosperous companies of its kind in the kingdom. Mr. Palmer was the first chairman of the company, and was largely responsible for the control of its first operations. He is also one of the principal shareholders in the works of the Bede Metal and Chemical Company on the Tyne. The works of this company are situated on the south bank of the river, about midway between Newcastle and South Shields. They are one of the few establishments called into existence in this country, in consequence of the use of cupreous pyrites as ores of sulphur in the manufacture of sulphuric acid. The burnt ore or residue of the pyrites, after the sulphur has been burnt out of it, contains about 4 per cent. of sulphur, 4 per cent. of copper, 55 per cent. of iron, 15 dwts. of silver, and 3 grains of gold to the ton. The ore is received from various chemical works, and it may be stated, as the manufacture is comparatively a new one, the first operation is that of crushing the ore to coarse powder mixed with common salt. It is next calcined, either in an ordinary long-bedded reverberatory furnace or in another form of furnace, so arranged that the working beds, which are formed by circular horizontal fans, revolve by machinery, dispensing entirely with manual labour, except such as is necessary for firing the furnace and regulating the mechanical arrangements for charging and withdrawing the ore. The first kind of furnace is capable of calcining 400 tons per week, and the latter can calcine 200 tons more. By the process of calcination, a soluble chloride of copper is formed through the combination of the copper previously existing in a partially soluble form, in the burnt ores, with the chlorine of the common salt in which they are mixed. The acids evolved by the process are drawn off from the furnaces through capacious flues by Schield's exhausting fans, and forced through a series of cooling pipes to condensers, in which, by bringing water into immediate contact with the gases the acid is dissolved, and is available in the subsequent lixiviating process. In its calcined state, the ore is thrown into wooden tanks where it is lixiviated, the residue forming a valuable iron ore,

GEMS OF THE VIENNA EXHIBITION.—VASE IN BRONZE AND SILVER BY CHRISTOFLE, OF PARIS. (Height, two mètres.)

used chiefly for fettling puddling furnaces. Part of this ore is used on the works for the manufacture of the iron necessary in precipitating the copper from the solutions obtained in the lixiviating process. Copper is precipitated in the metallic state, but by a new method patented by this company, the use of iron as a precipitant is dispensed with, and soda salt utilized. About 40 tons of copper per week is produced at the works of the Bede Company.

Returning for a moment to Mr. Palmer's shipbuilding career, we must notice, as one of the most important events of his life, the transference of the Jarrow works, in 1865, to a limited liability company, with a capital of two millions sterling. In the new company Mr. Palmer is the principal shareholder and chairman of the board of directors. The prestige of the Jarrow works is still as great as it has ever been, no shipbuilding establishment in the north of England turning out a larger annual tonnage.

In taking a survey of Mr. Palmer's business connections, it is impossible to avoid a feeling of amazement that one pair of shoulders should carry such a heavy burden so lightly. One of the largest colliery owners in the county of Durham, he is not satisfied with producing a million and a half tons of coal per annum from the collieries he has already in operation, but he is now making arrangements for opening up new workings near Sunderland, from which it is intended to raise something like another million tons per annum. He is president of the British Glass Association, and the chief shareholder in the Tyne Plate Glass Company. He is principal of the firm of Palmer, Hall and Company, carrying on a varied and extensive business in Newcastle as shipbrokers, shipowners, timber and general merchants, and saw-mill owners. As the leading shipbuilder on the Tyne, he has for some years been president of the Tyneside Shipbuilders' Association. Of the many private companies in which he holds shares it is impossible to speak. His honorary appointments are scarcely less numerous than his trade connections. Justice of the Peace for the North Riding of Yorkshire, also Justice of the Peace for the County of Durham, Lieutenant-colonel of the Jarrow Engineers, and Member of Parliament of the northern division for the county of Durham, he holds at the same time many public and honorary offices of minor importance. Take him all round, and he fully answers the description of

> "A man so various that he seemed to be
> Not one, but all mankind's epitome."

To the British House of Commons a man of Mr. Palmer's vast business experience, commercial sagacity, and intimate knowledge of the leading industries of England, must be a valuable acquisition; and it is matter for congratulation that he has at last found a seat in that august assembly. With such a variety of business engagements on hand, Mr. Palmer was in no hurry to enter parliament. He first became a candidate for parliamentary honours in 1860, when he unsuccessfully contested South Shields against the present member, Mr. J. C. Stevenson. For a long time previous to the last election he was spoken of as a probable candidate for the representation of Gateshead, in succession to Sir William Hutt. It was known that the latter gentleman, after representing the constituency in several parliaments, intended to resign, and Gateshead was courted by many suitors, including Mr. W. H. James and Mr. Lloyd Jones; but the latter gentleman did not put in an appearance when the dissolution of parliament was declared, and as Mr. James had been early in the field, Mr. Palmer, to avoid breaking up the Liberal party, and thus make way for a Conservative, resolved to withdraw his intended candidature for Gateshead. He had not long to wait before another constituency courted his services. Through the columns of the "Newcastle Daily Chronicle"—the leading Liberal journal in the north of England—it was announced that Sir Hedworth Williamson (Liberal) and Mr. George Elliot (Conservative), the representatives of North Durham in the moribund Parliament, had entered into a compact not to allow the division to be contested. This disclosure provoked so much indignation that Sir Hedworth Williamson retired, and Mr. Palmer was invited to come forward in his stead, conjointly with Mr. Isaac Lowthian Bell, President of the Iron and Steel Institute, and one of the first metallurgical chemists of the day. The result of the election was the return of both Mr. Palmer and Mr. Bell; and we may here be allowed to say, without trenching on the forbidden ground of political predilection, that two men more eminently representative of the leading industries of the north of England could not possibly be found.

RUSSIAN SYSTEM OF WROUGHT-IRON ROOF COVERINGS.

THE difference which exists in the habitations of mankind, from the snow hut of the Esquimaux to the palace of the Oriental, is due in great measure to climatic influence. That a habitation should be cool in summer and warm in winter is necessary to the comfort as well as to the health of the inmates. Independently of other points to be attended to in domestic architecture, the construction of the roof has an intimate bearing upon this desideratum. It is not too much to assert that the top rooms of many of our houses, which are built on a scale of magnitude and decoration which justly entitle them to be termed mansions, are almost unbearable from the heat in summer and from the opposite cause in winter. It is not always that even a high-pitched roof is water-tight; but the manner in which to impart that indispensable feature to a flat one is yet unknown to our builders. If the flat be constructed in several plates or sheets of any material, there appears to be no joint yet discovered which will not leak; and if it be composed of one single superficies, there remains to be invented a composition, cement, or mastic, which will stand the alternate wetting and drying, which tries to the utmost the roofs of houses and buildings in this country. Where the top rooms are not intended to be inhabited, as in Russia, the endeavours of the architect are directed more to making the roof water-tight and snow-tight than to fulfil the conditions which we have alluded to respecting the temperature.

The distinguishing characteristic of the Russian mode of covering their houses is that the material adopted is the ordinary iron plate made in the country. Each proprietor paints his roof of the colour which he most affects, and as tastes in this respect vary considerably, the result is that a very gay and picturesque appearance is afforded to a comprehensive *coup d'œil* of the roofs. The principle is an economical one in two ways. The first cost is small, and the maintenance of the covering in a sound and water-tight condition in the same proportion. The working details are simple, and adequate provision is made for a degree of expansion and contraction which is considerable, when it is borne in mind that the extreme variations of the thermometer embrace a range of 177 degrees Fahrenheit. The general precautions taken by the Russian architect against cold, in the houses he designs, are independent of the roof, and do not extend so far as the attic story, which is inhabited only in the summer time. During the winter season it is used as a drying room for the linen of the establishment. The main object of the architect is therefore limited to the construction of a covering which shall be water-tight, which shall be firmly fixed to the framework of the roof without overloading it, and shall besides possess every facility for dilating and contracting with the great variations of temperature to which it is subjected. The principals, which are of timber, are spaced at regular intervals either of 6 feet or 6 feet 6 inches apart from centre to centre, and are covered by lathwork, the laths being laid at right angles to the rafters. Upon these laths the iron covering is placed. The rafters are thus united by a complete framework of laths, which are spaced about 10 inches apart. In order to avoid the rotting which would inevitably attend the introduction of planking, the iron sheets are laid directly upon the lathwork. Another advantage of this arrangement is that the roof is very much lightened in consequence. The laths consist of small pine trees about 40 feet in length, and having a diameter at the larger end ranging from $3\frac{1}{2}$ to $4\frac{1}{2}$ inches. These saplings are obtained on the spot for rather less than a halfpenny per foot run. A plane surface is adzed to receive the sheets, and on the under side a groove is cut at intervals corresponding to the distances apart of the principals, in order to fasten them to the rafters, and make the whole roof more solid and durable.

When the laths, although their dimensions are somewhat in excess of those to which the term is generally applied, are fixed securely, the roof is ready for covering. The covering is performed by men who serve no apprenticeship to the business, but are handy fellows, who readily learn so simple an operation. The wrought-iron sheets are 3 feet 9 inches in length by 2 feet 4 inches in breadth. The first step consists in uniting the sheets in strips or bands the whole length of the rafter, and this must be accomplished without making any projections or asperities in the surface, which might act as impediments to the flow of the water off the roof. The operation is commenced by turning up the upper edge of the sheet and turning down the lower. When all the sheets comprising one strip or band are thus prepared, they are joined by hammering down the turned-over ends of each sheet, thus forming a very tight and effective

joint. By arranging the sheets so that the ends shall lap, it is impossible for the rain to penetrate even in the most violent storm. The pitch of roof which is found the best suited to the climate of the country is one of 20 degrees; but the covering will remain thoroughly water-tight at an angle of only half this amount, or 10 degrees. The sheets having been put together in strips, it remains to describe in what manner the strips themselves are united so as to form the complete covering. Before the sheets are brought to the works, after two of the edges have been turned up and down, the remaining longitudinal edges are also turned up, but not to the same extent. One edge, on the shorter, is turned up to the extent of three-quarters of an inch or an inch, and the other to 1¼ to 1½ inches. The smaller rim is turned up on the left edge of the sheet, and the larger on the right, so that when the sheets are placed side by side, the smaller rim of the one is in juxtaposition with the larger rim of the next, and so on in succession. The joint is made by bending the larger rim over the smaller; but, before this operation is accomplished, the sheets must be fixed down to the framework without making any nail holes. This is effected in a very simple and original manner. The sheets are obtained from the manufacturers in the Ural district in bundles containing sixteen in number, and weighing about 76 lbs., and bound together by the strips or shavings of metal which are cut off in the process of manufacture to reduce the sheets to the correct dimensions. The strips of metal which bind each bundle of sheets, suffice for their fixing, so that the most stringent economist would be satisfied with so minute a utilization of material. The strips are cut into pieces four inches long, one inch wide, and have one end turned over to a depth of half an inch. A small hole is pierced with a hand-punch at the lower end. The breadth of these strips is not constant, as can be imagined from the manner in which they are produced, but varies from 0·8 to 1·4 inches; but as they are not seen after the sheets are laid, the discrepancy is of no consequence. In fixing the separate lengths of sheets upon the timber framework, one of these strips, cut and prepared in the manner described, is inserted between the turned up small and large rims respectively of the sheets in such a manner that the rim of the strip laps over the small rim of the sheet, while at the same time the large rim of the sheet laps over the other two. The joint is made good by hammering closely all the rims together. The other end of the strip is bent round the lower surface of the laths, and nailed to them through the hole made for the purpose.

The joints at the ridge, the hips, in valleys and wherever two planes intersect, are made in the same manner in which the joints of the separate lengths are arranged, except that the rims which are in the one case projecting, are in the other flattened down. The method adopted of fixing the gutters is deserving of attention, insomuch as no bracket or support of any kind is employed. They consist of pieces of the same sheets used in the rest of the covering, turned over and flattened down in a similar manner. They are placed with a slight fall, and lead into the down pipes. To fix them in position the lower horizontal edge of the row of sheets to the right of the gutter is cut to the proper length, and turned down to a depth of about three-quarters of an inch. The edge of the gutter-piece is similarly turned up, a covering piece added, and the whole hammered tightly together. When the whole work is completed, the appearance is that of a number of parallel bands running the whole length of the roof, from the ridge to the eaves, and presenting a perfectly plane surface, since the horizontal joints have not sufficient projection to be noticed at a distance. The effect to the eye is very agreeable. The task of the workman is very much facilitated by the introduction of the laths, and there is not, besides, the risk of his slipping, as in the case in which smooth planking is used. The tools and appliances required are reduced to a minimum both in number and cost, and consist of a piece of flat bar-iron with rounded edges to turn up the rims on the sheets, a wooden mallet, a small punch, and a common hammer. One great advantage of this mode of covering roofs is that it can be readily examined both on the outside and the inside, and if care be taken to paint it at the proper seasons, it will last for a period of thirty years. Before fixing the sheets the under surface is coated with a layer of tar, which is never removed, unless oxidation should commence in consequence of the formation of foul gases in the attics, a circumstance of rare occurrence.

With respect to the price of this method of roof covering, the cost per square foot, including painting, fixing, and all other charges, is three halfpence. The price for fixing the gutter per lineal foot is about the same. Care must be taken in turning over the rims of the sheets that angles with sharp edges are not formed, for in that case the sheets would split under the influence of the expansion and contraction of the metal. To avoid this the rims are turned over a bar with rounded edges, and the sheets are at liberty to approach or recede from each other without any damage arising. It is stated upon good authority that there are roofs of this description existing in Russia which were put up in 1812. It is true that these examples are in very bad condition, and require to be renewed, but they have nevertheless lasted for sixty years. The iron is of excellent quality, and is manufactured at the Demidoff workshops.

WELDON'S PROCESS FOR UTILIZING DILUTE CHLORINE.

MR. WELDON has recently proposed two new methods for the preparation of chlorine. They consist in passing mixtures of hydrochloric acid gas and air over surfaces of sulphate of copper or other catalytic agent, or by treating a metallic chloride, or a mixture of a metallic chloride, or metallic chlorides, with a metallic oxide or other body, by either sulphurous acid gas and air, or by sulphuric anhydride and air, or by sulphuric anhydride only, or by heating, with access of air, either chloride of magnesium, chloride of iron, or chloride of copper, or any mixture of a metallic chloride or metallic chlorides, with a metallic sulphide or metallic sulphides, or with a metallic sulphate or metallic sulphates, or with a metallic phosphate or metallic phosphates.

The chlorine obtained by either of these processes is, however, so diluted with other gases, that it cannot advantageously be employed in the production of bleaching powder. It has, therefore, to be concentrated, and this is effected by treating it with milk of lime in such a manner as to produce a mixed solution of chloride and hypochlorite of calcium, and in then decomposing this mixed solution by aqueous or gaseous hydrochloric acid. The excess of lime, which has not been attacked by the chlorine, is to be separated from the resulting mixed solution of chloride and hypochlorite of calcium, before treating this solution with hydrochloric acid, and the lime thus separated may be employed in a subsequent operation of absorption of dilute chlorine. The separation is best performed by subsidence and decantation.

The reaction between aqueous hydrochloric acid and any solution, either of a chlorate, or of a hypochlorite, or of free hypochlorous acid, obtained by treating dilute chlorine by milk of lime, takes place in a closed still, into which the liquors are admitted by a hydraulic lute. In performing this part of the operation it is preferred to put the hydrochloric acid into the still first, and to add the other reagent thereto gradually, in a more or less continuous stream, and as nearly as may be at such rate only as that at which its decomposition is effected. The work could also be done by putting the other reagent into the still first, and adding the hydrochloric acid thereto gradually; but in this method of working there is risk of a decomposition in which oxygen shall be set free, and which may take place with explosive violence. When the other reagent is one which hydrochloric acid will not completely decompose without the aid of heat, steam is injected into the still in which the two bodies are treated together, or its contents heated by any other convenient means.

Another mode of bringing about the decomposition is to run the two liquors *simultaneously* into the closed still, the two streams being so proportioned that the quantity of the one which enters the still in an unit of time shall be just sufficient, or as nearly as possible so, to decompose the quantity of the other which enters in the same time. For working in this way it is proposed to use a still from which the residual product of the reaction taking place in it may run out continuously, or if not continuously, in measure as the solutions which are to react on each other enter it.

Among the gases and vapours diluting the chlorine, to the treatment of which the present process applies, will usually be some vapour of hydrochloric acid. This should be washed out of the mixture of gases before commencing the treatment of the chlorine contained therein. It will thus be obtained as a dilute aqueous solution, too weak for most of the purposes for which aqueous hydrochloric acid is required in the arts. It will be strong enough however for the decomposition of the product of the treatment of dilute chlorine by a milk or solution of an oxide or of a salt, and a part of the new invention consists in applying it thereto, and in similarly applying also the weak acid from the "wash towers" in which are condensed the last portions of the acid from salt cake roasters.

The absorption of the dilute chlorine by milk of lime is effected in a series of towers, so arranged and worked that the gases

which pass from the first of them shall be made to pass through the second, and the gases which pass off from the second be made to pass through the third, and so on, the gases being in each case conveyed from the top of one tower to the bottom of the next, and that each time the charge of milk or solution of oxide or salt treated in the first tower has absorbed sufficient chlorine, and has accordingly been run off, the charge of the second tower shall be transferred to the first tower, and the charge of the third to the second, and so on, the last tower of the series being then recharged with fresh milk or solution, as the case may be. The milk or solution employed will usually require to pass through each tower a more or less considerable number of times, according to the height of the towers. Each tower should therefore communicate with a reservoir, suitably placed below it, which shall receive the charge from the tower, and from which the charge can be pumped or otherwise elevated to the top of the tower as often as need be. If these reservoirs or receivers be placed at successively higher elevations, and be suitably connected together, the charge of the second tower can be run off from the reservoir or receiver below that tower into the reservoir or receiver below the first tower, and the charge of the third tower into the reservoir or receiver belonging to the second tower, and so on, by simply opening appropriate cocks or valves. The towers must, of course, be closed at the top, the milk or solution entering them by openings protected by hydraulic lutes. They may conveniently be packed with what are known as "soap bricks," arranged in pigeon-hole fashion, as is well understood. The last tower of the series should be connected by a flue with either a chimney or a mechanical aspirator.

THE CHEMICAL ACTION OF THE BLAST FURNACE.

DR. ALDER WRIGHT gave on March 13th a lecture at the Royal Institution on the chemical changes accompanying the smelting of iron in blast furnaces. After briefly describing the general arrangements and construction of a blast furnace, the lecturer stated that the nature of the ore used necessarily exerts a great influence on the chemical changes that take place. The following Table indicates the general composition of several of the chief descriptions of ore used. In some instances the iron exists naturally as ferric oxide; in other cases chiefly as ferrous carbonate.

	Hæmatite.	Magnetic Ore.	Spathic Ore.	Clay Ironstone.	Brown Ore.
Fe_2O_3 . .	90-100	30-70	0-3	0-3	40-70
FeO . . .	—	13-33	36-50	35-55	0-5
Al_2O_3 . .	0-2	0-5	0-2	1-7	1-7
CaO . . .	0-3	0-5	0-4	1-14	1-7
MgO . .	0-1	0-2	0-4	1-9	0-2
MnO . .	0-1	0-1	1-25	0-2	0-3
SiO_2 . .	0-10	0-10	0-5	2-17	1-35
CO_2 . .	0-1	0-10	37-42	22-37	0-5
P_2O_5 . .	0-1	0-2	trace	0-2	0-2
SO_3 . . .	0-1	trace	„	0-3	trace
H_2O . .	0-1	0-4	—	0-1	6-18
Essential Composition.	Fe_2O_3 with little or no earthy matter.	Fe_2O_3 and FeO with earthy matters.	$FeCO_3$ and $MnCO_3$ crystalline.	$FeCO_3$ and much earthy matter.	Hydrated Fe_2O_3 and earthy matters.

When ferrous carbonate constitutes the ore used, the smelting process is usually facilitated by submitting it to a previous calcination in a kiln like a lime-kiln, whereby the ferrous carbonate becomes transformed into ferric oxide; when, however, the carbonate is not calcined before use, it speedily loses the carbon dioxide present therein, leaving behind an oxide of iron; this occurs in the top portion of the furnace, so that virtually the ores used may be regarded as consisting essentially of some form of iron oxide, with a varying amount of earthy matter of variable kind intermixed therewith.

The fuel used is ordinarily coke or charcoal; when, however, raw coal is employed, it is completely coked in the top portion of the furnace, so that the fuel burnt at the tuyères is invariably carbon.

As the blast enters the furnace it comes in contact with a mass of incandescent carbon, whereby its oxygen is firstly converted into carbon dioxide, and nextly into carbon oxide, the nitrogen for the most part remaining unchanged; not impossibly, a good deal of the carbon is burnt directly to carbon oxide, without passing through the intermediate stage of carbon dioxide; any moisture present in the blast is similarly converted into a mixture of carbon oxide and hydrogen; the amount of the latter necessarily varies with the hygrometric state of the atmosphere. Although hydrogen is a powerful reducing agent, the influence of the small quantity present in the blast-furnace gases appears to be practically *nil;* the gases issuing at the top of the furnace contain on an average about as much free hydrogen as is brought in by the blast, whence it is evident that the hydrogen has contributed little or nothing to the reduction of the ferric oxide; and again, practical experience shows that the more moisture enters the furnace at the base, the more fuel is requisite to do the work, *i.e.* the development of hydrogen is injurious to the action rather than auxiliary.

The action of the mixture of nitrogen and carbon oxide thus formed at the tuyères is far more complex than is usually supposed; the carbon oxide is ordinarily considered to act on the oxide of iron, removing its oxygen and forming carbon dioxide; but this simple action is complicated by several others, some of which are of a contrary nature, so that the end result at any given point in the furnace is that due to the single resultant of a number of opposed forces. The following table illustrates the character of these various actions.

TABLE OF CHEMICAL CHANGES TAKING PLACE IN DIFFERENT PARTS OF THE BLAST FURNACE.

[A] Reduction of higher oxide to lower oxide and metal by gaseous carbon oxide.

(1) $Fe_x\ O_y + CO = Fe_x\ O_{y-1} + CO_2$
(2) $Fe_x\ O_y + yCO = xFe + yCO_2$

[B] Oxidation of metal to lower oxide and higher oxide by carbon dioxide.

(3) $xFe + yCO_2 = Fe_x\ O_y + yCO$
(4) $Fe_x\ O_{y-1} + CO_2 = Fe_x\ O_y + CO$

[C] Reduction of carbon oxide to carbon.

(5) $xFe + yCO = Fe_x\ O_y + yC$
(6) $Fe_x\ O_{y-1} + CO = Fe_x\ O_y + C$

[D] Reaction of reduced carbon on iron oxide forming carbon dioxide.

(7) $2Fe_x\ O_y + C = CO_2 + 2Fe_x\ O_{y-1}$
(8) $2Fe_x\ O_y + yC = yCO_2 + 2xFe$

[E] Reaction of carbon dioxide on reduced carbon.

(9) $CO_2 + C = 2CO$

The reactions classified as [A] and [B] are thus the reciprocals of each other respectively; whilst [A] and [D] concur together in assisting the reduction of the iron oxide, [B] and [C] have the opposite tendency; changes [C] promote the deposition of solid carbon from the furnace gases, whilst [D] and [E] cause the oxidation and gasefaction of the deposited carbon.

Each one of these changes was made the subject of experimental illustration, and the results of a large number of investigations thereon were referred to and exhibited in the form of diagrams: the recent investigations of J. Lowthian Bell (with whom the lecturer had co-operated in his researches) being more particularly discussed.

The action of carbon oxide on iron oxide in accordance with reactions [A] is perceptible at temperatures but little elevated, the precise temperature depending on the physical structure of the ferric oxide used. Thus—

TEMPERATURE AT WHICH CARBON OXIDE BEGINS TO REDUCE FERRIC OXIDE.

Substance.	Minimum Temperature at which Carbon Dioxide is formed.	Temperature at which action is well marked.
	°	°
Precipitated by ammonia . . .	141	149
Calcination of ferric nitrate . .	145	154
Average calcined Cleveland ironstone	199	210
Ditto, more highly calcined . .	200	206
Calcination of ferrous sulphate . .	208	216
Pumice-stone soaked in ferrous sulphate solution and calcined .	211	227

Certain connections between the heat developed by the union of bodies with oxygen and the mutual reactions of the oxidized products on the bodies severally, were referred to; the opposite reactions [A] and [B], can occur because iron and carbon oxide develope approximately the same amounts of heat in uniting with a given quantity of oxygen; whilst copper oxide is decomposed by carbon oxide forming metallic copper and carbon dioxide, but the opposite change is *not* produced, because *less* heat is given out by copper than is produced by carbon oxide on uniting with a given weight of oxygen. Thus when the changes occur at 500°, the following amounts of heat are given out per 16 grammes of oxygen consumed—

Combustible.	Product of Combustion.	Kilogramme heat units evolved at 500°.
Iron	Magnetic (and probably any other) oxide	66·7
Carbon oxide	Carbon dioxide.	68·8
Carbon	Carbon oxide	27·4
Carbon	Carbon dioxide	48·1
Hydrogen	Steam	58·9
Copper	Cuprous oxide	37·6
	Cupric oxide	

Since iron and hydrogen evolve approximately the same quantities of heat in uniting with oxygen, the converse changes brought about when steam acts on iron, or hydrogen on iron oxide, are analogous to the converse reactions [A] and [B]: similarly nickel and cobalt possess about the same oxidation-heat as iron, and hence are similarly affected by carbon dioxide, though with somewhat less ease. Thus—

Comparative Action of Carbon Dioxide on Iron, Nickel, and Cobalt, at about 600°.

Iron	100
Cobalt	44
Nickel	11
Iron first begins to act	below 420°
Cobalt „ „	about 550°
Nickel „ „	above 550°

Again, reactions [C] occur because iron evolves more heat in uniting with a given weight of oxygen than solid carbon does (carbon oxide being the product). Reactions [D] and [E] are abnormal in this respect.

From the existence of the inverse reactions [A] and [B] it results that when a mixture of the two oxides of carbon acts either on metallic iron or on iron oxide, oxidation of the one or reduction of the other takes place until a definite relation exists between the iron and oxygen present in the resulting substance and the two oxides of carbon in the gaseous mixture; the composition of the inert substance necessarily varies with the temperature and the nature of the mixture of the carbon oxides used; the higher the temperature and the more carbon dioxide is present, the larger is the amount of oxygen present in the inert substance. Thus Bell obtained the following numbers :—

CO_2 per 100 volumes of CO.	Temperature.	Oxygen in inert Oxide Fe_2O_3 = 100.	Carbon deposited per 100 of Fe.
600	Red heat	90·0	nil
100	Bright red heat	67·5	„
47	Full red heat	8·2	„
11	Approaching whiteness	11·9	„
Nil (pure CO)	Bright red heat	1·0	0·3

The following tables exhibit respectively the influence of the physical condition of the iron oxide used in the first instance as a source of iron or its lower oxides, on the rate at which reactions [C] take place; and the comparative action of carbon oxide at 400°—500° on various metals and oxides.

Carbon deposited from various kinds of Ferric Oxide by simultaneous exposure to Carbon Oxide at 420° for 7 Hours.

	Carbon deposited per 100 of iron
Calcined ferric nitrate	144·0
Precipitated by ammonia	95·4
Calcined ferrous sulphate	54·5
Pumice-stone soaked in ferrous sulphate and calcined	14·9
Calcined Cleveland ironstone	0·3

After ten or twelve hours, however, the discrepancy is not so marked, as much carbon being then deposited with the Cleveland ore as is with the precipitated oxide in seven hours.

Comparative Action at 400°—500° of Carbon Oxides on various Metals and Oxides.

Higher oxides of iron, nickel, and cobalt;
Reduced to lower oxides, and partially to metal; sub-oxides (Fe_2O, Ni_2O, and Co_2O) being formed, and much carbon deposited.

Spongy metallic iron, nickel, and cobalt;
Partially oxidized, much free carbon being formed; iron most active, nickel least.

Higher oxides of manganese;
Reduced only to monoxide (MnO); no free carbon being deposited.

Oxides of copper and lead;
Reduced to metals; no free carbon deposited.

Oxides of zinc, chromium and tin; metallic copper, lead, zinc, and tin;
No effect.

The gases of the blast furnace contain not merely carbon oxide and carbon dioxide, but also a large bulk of nitrogen; all experience, however, goes to prove that this acts solely as a diluent, and in no way interferes with the above-described reactions, saving in delaying them, *i.e.* causing more time to be required for their performance; the presence of nitrogen is, however, of great importance as regards another set of chemical reactions taking place in the lower portions of the furnace.

It has long been known that when nascent potassium or sodium vapour finds itself simultaneously in contact with carbon and nitrogen, the three elements combine, forming a metallic cyanide; the production of cyanide in this way was experimentally demonstrated by means of a small model blast furnace.

The cyanide thus formed acts on the last portions of unreduced oxide of iron, converting it into metal and becoming itself changed to cyanate; at the high temperature of the furnace near the tuyères this cyanate is probably decomposed with the formation of an alkaline carbonate, and the elimination of nitrogen: a portion of the alkaline carbonate is again converted into cyanide; the majority, however, escapes, and is carried upwards by the stream of gases, and condenses as a kind of sublimate on the surface of the materials in the upper part of the furnace; considerable quantities of cyanides are also carried up in this way. The alkaline salts thus condensed in the upper portions of the furnace are again brought down to the level of the tuyères as the materials sink; hence each particle of alkali metal does duty over and over again, the alkalies introduced in small quantities in the fuel, &c., accumulating in the furnace to a very large extent. It appears very probable that the large excess of fuel required during the first few days of starting a new blast furnace is mainly due to the circumstance that cyanides have not formed to any great extent from the necessary want of this accumulation; after a very short time, however, considerable amounts of cyanides are found to be present in the gases.

The enormous amounts of upwards of 4 cwt. of alkali metals and 2 cwt. of cyanogen per ton of iron made, have been repeatedly found in the gases of that part of the furnace just above the level of the tuyères.

These actions afford an explanation of an apparent anomaly as regards the relative compositions of the furnace gases at various levels: all experimenters agree that when the carbon and oxygen in the gases are calculated relatively to the nitrogen, there is always an excess of the former two in all parts of the furnace over and above that due to the air blown in at the tuyères and the carbon taken up by the oxygen therein present; thus the following table illustrates the average composition by weight found by Bell in the case of an 80-foot furnace using calcined limestone :—

Distance above Tuyère in feet.	0	6	12	25	37	50	60	76·5	Blast if wholly burnt.	
									To CO.	To CO_2.
Carbon dioxide	1·2	trace	0·8	1·2	2·6	1·2	3·5	7·9	—	29·2
Carbon oxide	37·6	37·1	35·9	34·9	34·8	34·8	33·2	33·0	34·4	—
Nitrogen	61·2	62·9	63·3	63·6	63·6	64·0	63·3	59·1	65·6	70·8

CARBON AND OXYGEN IN THE GASES AT DIFFERENT LEVELS, CALCULATED PER 100 OF NITROGEN.

Carbon . .	26·8	25·2	24·6	23·9	24·1	23·8	24·0	27·5	22·5	11·3
Oxygen . .	36·5	33·7	33·3	32·6	33·1	32·4	33·9	41·6	30·0	30·0

The presence of this excess of oxygen is readily accounted for when it is remembered that even at the lowest portions of the furnace some oxygen is still left in the ore, which is eliminated only at that point, necessarily in association with carbon, and that at this level the nitrogen of the blast is partially removed in the formation of cyanides. The anomaly, however, presents itself that the amount of oxygen appears to *diminish* from the tuyères to a point some 10—12 feet above them, whereas it might be expected to increase, since the reduction of iron oxide is going on in the interval between the tuyères and 10 feet above them; inasmuch, however, as nitrogen is probably eliminated from the cyanide by its reaction on the residual oxide of iron throughout the whole of this interval, it results that *the nitrogen increases relatively to the carbon and oxygen in the gases;* or, what is the same thing, these diminish in reference to the nitrogen.

The chemical actions of the furnace as regards the smelting of iron may on the whole be briefly described thus; the furnace may be considered as divided into three regions: in the uppermost tendencies [A] and [D] jointly are stronger than [B] and [C] jointly, and hence rapid reduction of ferric oxide takes place: in this region, too, tendency [C] is more powerful than [D] and [E] jointly, and hence carbon deposition takes place to a large extent. In this region, too, the limestone is for the most part calcined into quicklime, whilst if raw coal is the fuel employed, it is here coked: if carbonate of iron be used instead of oxide, it becomes converted into oxide in this region, the reducing and carbon-depositing reactions going on simultaneously with the formation of oxide.

In the middle region the iron-reducing tendencies are almost balanced by the iron-oxidizing ones, whilst the carbon-depositing tendencies are equalled and perhaps slightly excelled by the carbon-oxidizing tendencies; here reduction takes place, but only languidly, the chief effect produced in passing through this region being an increase of temperature.

In the lowest region, the reduction of the residual iron oxide is completed chiefly through the agency of the cyanides formed in the vicinity of the tuyère; the reduced iron melts, dissolving a certain amount of the finely-divided carbon in contact with it, together with small quantities of sulphur, silicon, and phosphorus reduced by subsidiary reactions. The earthy constituents of the ore and the lime of the limestone also fuse, forming "slag." In the act of cooling, this solution of amorphous carbon in molten pig iron undergoes a remarkable change, whereby the carbon is converted to a greater or less extent into the allotropic modification graphite, which is insoluble in molten iron, and so separates in crystals, thereby giving a crystalline structure to the pig, and forming "grey" iron of a quality varying with the nature of the foreign ingredients which retard the allotropic transformation; thus in white iron and in spiegel-eisen the transformation does not take place to any appreciable extent before solidification. This allotropic change is precisely similar to that undergone by a solution of yellow phosphorus in carbon disulphide by exposure to light; in each case the more stable allotrope formed (graphite and red phosphorus) possesses less "intrinsic chemical energy," *i.e.*, gives out less heat on combustion, so that the allotropic change is attended with an evolution of heat.

Specimens illustrating these changes were exhibited.

The practical consequences deducible from the investigations described are of great importance. In order to effect the smelting of iron a certain definite amount of heat is required to perform the general work of the furnace; the various items in this amount are indicated by the following table:—

APPROPRIATION OF HEAT IN AN 80-FOOT FURNACE DURING THE PRODUCTION OF 20 CWT. OF PIG-IRON FROM CLEVELAND ORE.

	Cwt. Heat-units.	
Constant requirements of furnace—		
Reduction of Fe from Fe_2O_3 . .	33,108	
Impregnation with carbon . . .	1,440	
Reduction of P, S, and Si . . .	4,174	
Fusion of pig iron	6,600	
Radiation from walls of furnace . .	3,658	
Cooling tuyères by water . . .	1,818	
Conduction to earth, and other sources of loss not determined . . .	3,202	
		54,000
Variable sources of loss of heat—		
Fusion of slag	16,720	
Expulsion of CO_2 from limestone .	5,054	
Decomposition of ditto	5,248	
Decomposition of H_2O in blast . .	2,720	
Evaporation of H_2O in coke . .	313	
		30,055
Carried out by escaping gases . . .		8,860
Total		92,915
Brought in by hot blast		11,919
Heat produced by combustion of coke .		80,996

To produce this heat with a minimum expenditure of fuel, it is necessary that the whole of the carbon used as fuel should be oxidized in the furnace to carbon dioxide; the relative strengths of the forces involved in the nine reactions above described are, however, such that it is not possible to convert more than about 35 or 40 per cent. of the carbon burnt into carbon dioxide, the rest necessarily escaping as carbon oxide. Hence much less heat is generated in the furnace than would be if the fuel could be wholly burnt to carbon dioxide; that is, more fuel must be used to do the work of the furnace. It hence results that if the exigencies of commerce or of nature should require that metallic iron should be obtained from its ores with the consumption of a materially less amount of fuel than is now necessary for the working of a blast furnace of the best description, some wholly dissimilar form of apparatus will be requisite for the purpose.—C. R. A. W.

THE MINES AND MANUFACTORIES OF UPPER SILESIA.[1]

FRIEDRICHS-HÜTTE.

(*Continued from page* 192.)

SINCE the year 1862, the authorities at Friedrichs-Hütte have substituted for the old plan of smelting in kiln-furnaces, the process known as "roasting and reaction," executed in reverberatory furnaces. The lead ores from the Frederic mine are generally very fine, containing a large quantity of oxide of lead, a quality that is extremely favourable for their treatment in the reverberatory furnace.

The powers of smelting the lead ores in the reverberatory furnaces rest upon the following bases:—

The sulphurets of lead necessarily become oxidized at contact with the oxygen in the air, under the influence of a slightly elevated temperature, and form oxides of lead, sulphuric acids, and sulphates of lead.

The oxide of lead, the sulphates of lead and the sulphurets of lead, mixed in certain conditions, should be reciprocally decomposed at a high temperature.

$$Pb\,S + 2\,Pb\,O = 3\,Pb + S\,O_2 \text{ and}$$
$$Pb\,S + 2\,Pb\,O\,SO_3 = 2\,Pb + 2\,SO_2$$

Following this chemical formula, the process of reduction in the reverbatory furnaces is divided into two operations.

The first—the period of roasting—consists in the production of the oxides of lead; the second—the period of smelting—in the reaction of these oxides upon the sulphurets of lead.

The more favourable the proportion between the oxides of lead and sulphate of lead, the more successful is the smelting process. The roasting or oxidation commences at the surface, and then penetrates the interior of the fragment; over-large grains would then still retain their sulphate of lead, and it would be difficult to ascertain the precise moment when the period of roasting should be terminated.

To avoid this inconvenience, they first pass the ore through a rolling mill, worked by an engine of from four to six-horse power, the cylinders being 25 inches. A simple sorting apparatus, with holes five millimetres large, separates the ore into different sizes, and that which is incompletely crushed is passed anew under the rolling mill.

Six reverberatory furnaces are in full activity at the Frederic mine.[2]

[1] Translated from "Les Grandes Usines" of M. Turgan.

[2] Teichmann, "Die Friedrichs-Hütte bei Tarnowitz in Ober-Schlesien," in the "Journal des Mines."

The furnace channel regulating the draught of the furnace, and the channel at the top of the roof, closing the charge of ore tightly up, consist of brick plates, very hardly and strongly baked, fitted with a frame of forged and flexible iron.

Above the reverbatory furnace there is a funnel, through which the charge of ore is put in. This funnel is fitted with a valve, which can be very easily moved.

The waggons, containing the charge, are by an ingenious system raised to the principal level of the furnace floors, and then drawn over rails to the top of the furnaces.

Between the furnace channel and the chimney, some 150 ft. high, a whole system of pipes, 1,300 ft. in all, is situated, through which the gases, freed during the roasting and the reduction of the ores, are obliged to pass.

These pipes, 8 ft. high, and 5½ ft. in circumference, receive all the fine fragments of the metal and a large quantity of oxidized metal, dust and smoke; thus the loss in the metal is sensibly diminished.

The lead vapours and the sulphuric acid, produced in very large quantities, have still 150 ft. of chimney to pass through before reaching the air, and almost the whole of them are deposited in the traject, and the evil influences which these gases exercise on the surrounding vegetation is in part neutralized.

The reverberatory furnaces are very successful, and, since their foundation in 1862, have worked without any interruption—the cost of repairs is insignificant.

The charge is composed of five or six kinds of metal, of different qualities and different densities; for the mixtures are varied according to the composition of the materials.

The ores to be treated should be sorted after their yield of silver, so as to obtain, as near as may be always the same outcome; for all the lead is deprived of its silver before coming into the market.

The average result of the ores treated has been :—

	Lead.	Silver.
1863	69·81 per cent.	·07640 per cent.
1864	74·01 „	·07341 „
1865	72·97 „	·07461 „

In 1862, after the introduction of the reverberatory furnaces at Friedrichs-Hütte, the charge was composed of 20 cwt. This charge has been gradually increased, 5 cwt. at a time, on account of the growing skill of the workmen trained in the foundry itself. In 1865, they attained the maximum of 40 cwt. to the charge.

The furnace is managed by two workmen, a smelter and an assistant; four men are appointed to each furnace, and work in couples, turn and turn about, every twelve hours.

The work is paid for by the day. As soon as the furnace is heated red-hot in all its parts, the charge of ore is introduced through the funnel, and the furnace hermetically sealed. The charge is from 3 to 4 inches high, and its surface is smoothed down.

A gentle fire is kept up with coal dust, and they are careful to maintain the furnace at a dull red heat throughout the whole process of roasting, so as to prevent the melting of the metal.

This temperature is higher than that necessary for the fusion of lead; and lower than that at which the galenas begin to soften; the heat may be estimated at from 500 to 600 degrees centigrade.

Coal-dust is employed not only on account of its cheapness, but more especially because the carbonic acid gases it forms are entirely oxides before reaching the interior of the furnace; consequently they have lost their property of rendering the lead fusible, which is not contrary to the end desired in the roasting. After the crackling of the galenas—active enough at first—has ceased, the mass attains a higher temperature, which increases at the end of three quarters of an hour, or an hour (the time during which the mass is turned), so as to let the roasting take place in the most active manner possible.

The channel is opened just sufficiently to allow the sulphuric acid which has escaped to become free; this feeble current of air permits the oxygen in the air to penetrate anew into the furnace.

By means of samples often drawn, especially from the surface, they are able to ascertain the progress of the oxidation, and to fix the moment when the mass should be turned. This work is executed every twenty or twenty-five minutes, and is repeated, more or less, according to the quality of the ores; but generally the mass is turned eight or nine times in all.

The period of roasting lasts from three to four hours; during this time the temperature is not high enough to soften the lead, so there is no loss of metal, even under the form of vapour.

Towards the close of the roasting operation, the fire is carefully stirred, and the heat augmented by degrees.

With a higher heat the mass, composed now of oxide of lead and sulphate of lead, softens very quickly, and decomposition takes place according to the formula indicated above. The metallic lead separates, becomes fusible, and, through the slope of the furnace, falls into a reservoir, while the softened mass is violently stirred with a scraper or turned with a shovel. At the same time the surface of the mass is covered with layers, thicker or thinner, of oxides and sub-sulphate of lead (Pb^2S), which flow to the walls of the surface, and are strewn from time to time with a shovelful of burnt lime very slightly moistened.

The furnace is then entirely filled with the vapour of lead, which, together with the other gases, escapes by the channel, where they are deposited under the form of a very fine white powder.

A sudden fusion of the entire mass should be avoided, because it would derange the regular work, and entail a heavy loss of metal. For this reason the heat of the fire and the regularity of the draught require the greatest attention upon the part of the workman.

An over-rapid fusion is prevented by the introduction of a few shovelsful of burnt lime.

As soon as the period of reaction commences, the fire is stirred about several times, but very regularly; and in the space of an hour, or an hour and a half, the reservoir is filled with lead; from thence it is taken out and poured into moulds. The oxides of lead which flow off are again cast into the furnace.

As the fire is frequently stirred during the period of fusion, the air comes in in considerable quantity, and accelerates the oxidation more and more; the temperature is lowered, and the fusion diminished in intensity by successive degrees.

As soon as ever the cooling has reached a certain stage, it is necessary to reclose the orifices in the furnace and increase the heat. The furnace is then, during a tolerably long time, filled with the gases produced by the combustion of the coal, and these favour the reduction. Their influence is very speedily felt; the metallic lead separates from the rest in large quantities, and fills the reservoir. While the heat in the furnace is being increased, it is essential not to neglect to move and turn about the mass, nor to forget to add lime, if the fusion is taking place too rapidly.

The heat is still increased, and at the end of an hour and a half or two hours the lead for the second time is withdrawn from the reservoir.

The same operations are repeated at least three times; naturally the lead diminishes in bulk at each operation, and the charge becomes more compact. During the final operation they add to the charge the dross or slag drawn from the reservoir, mixed with small coal or coal dust.

The period of melting occupies about seven hours; the residuum of the charge (about four to six cwt.) is poured into an iron box filled with water.

All this work is, with a little care, at present executed without any danger, and has resulted in diminishing the vapours that were so hurtful to the health of the men employed.

This labour ended, the furnace is completely cleaned and repaired.

Four kiln-furnaces have been retained for the treatment of certain ores which cannot be passed into the outer furnaces without undergoing a preliminary preparation; these kiln-furnaces serve also to treat the different residues.

The whole of the lead produced by the reverberatory furnaces, as well as the major part produced by the kiln furnaces, were formerly treated by crystallization on the Pattinson system. Although for the last year and a half the process has been abandoned, it has become so celebrated that we nevertheless feel obliged to borrow a description of it from Teichmann, the experimental metallurgist, who has presided with so much tact and intelligence over the various transformations which Friedrichs-Hütte has undergone during several years.

This process, invented by Hugh Lee Pattinson, in Northumberland in 1833, was intended to treat large masses of lead which were very deficient in silver.

The success of the process depends upon a perfectly even degree of temperature, and it is necessary to operate upon a mass of at least 50 cwt.

The following are the four circumstances which work together in the Pattinson process :

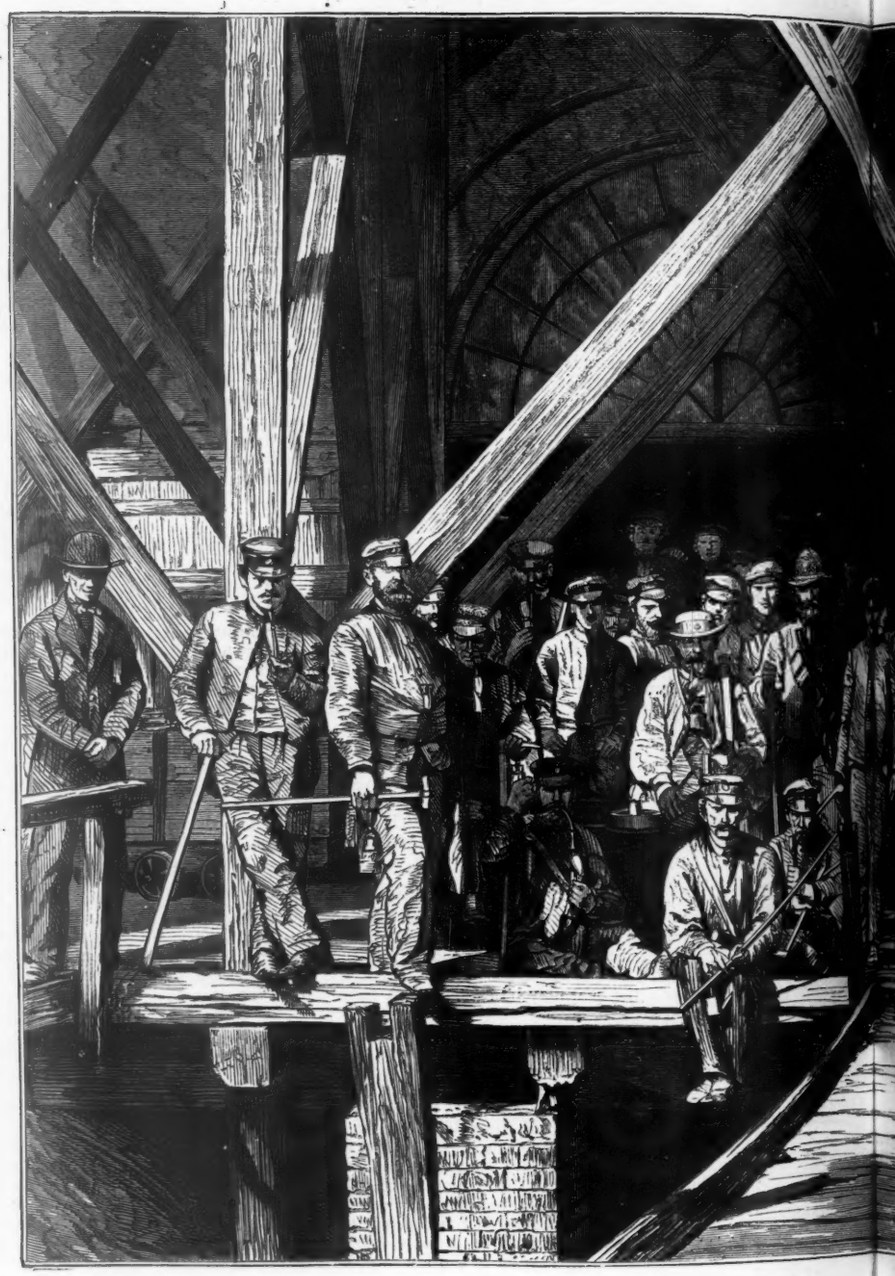
After the cooling of the molten mass, the crystallization acts more especially upon the molecules of pure lead.

The melting degree of amalgams within silver is less than that of pure lead.

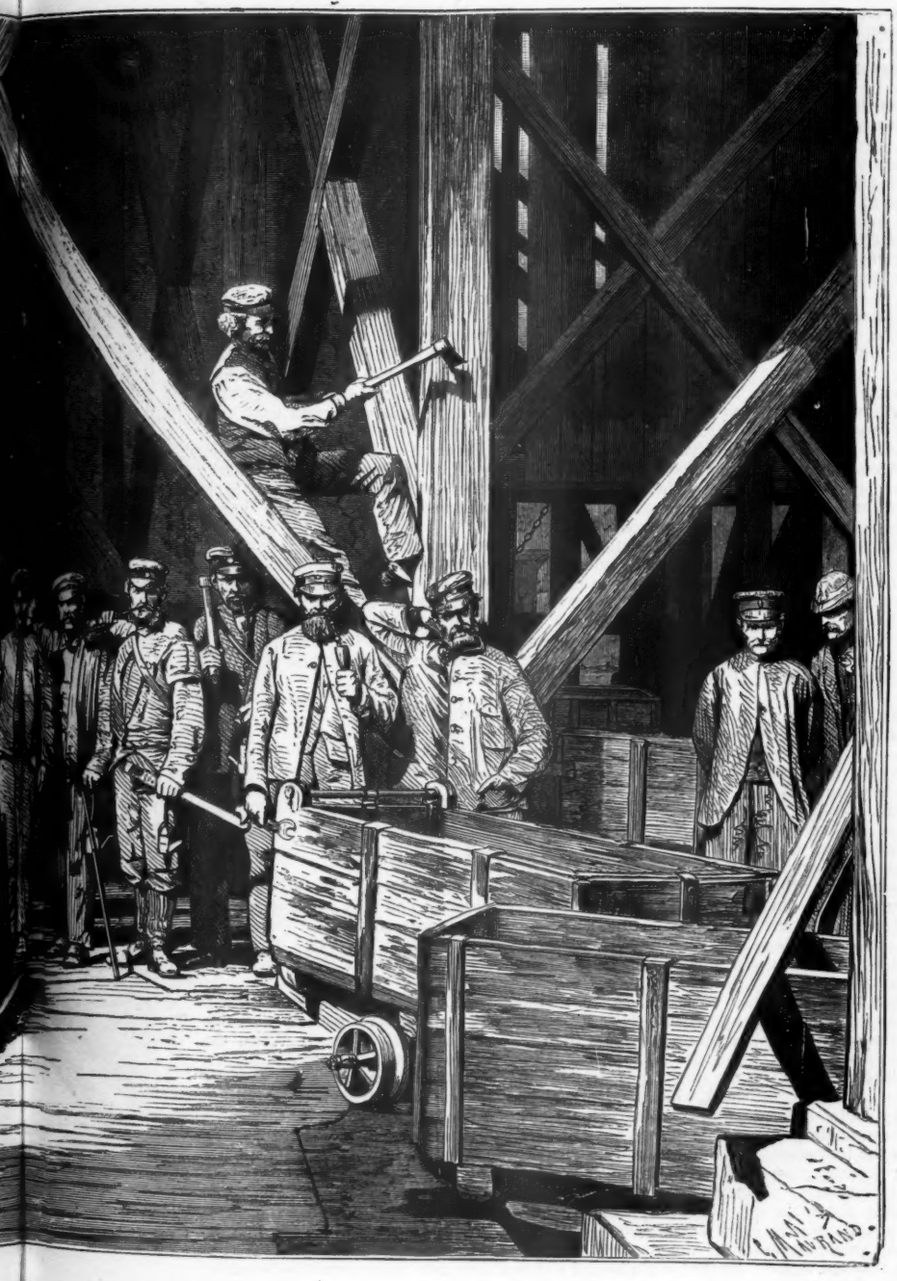
At the moment the crystals form, the latent heat becomes free, and communicates itself to the amalgam, remaining in a molten state.

The amalgam possesses a specific heat less than that of pure lead.

The whole of the lead which has to be treated by the process



GROUP OF COLLIERS BELONGING TO



GIN TO THE "MATHILDE" COAL PIT.

XUM

of crystallization is found, after the first operation, to be divided into two portions; the one consisting of crystals of compact lead; the other of a liquid mass rich in silver. The crystals are separated from the portion remaining liquid, either by withdrawing the solid part, or by pouring off the other; but they cannot hinder the crystals, on account of adhesion, retaining some share of the amalgam which is rich in silver.

Each of these portions again undergoes the same process of crystallization and the same separation; and finally, the sum of the lead treated is divided into fragments in which the yield of silver increases, and into fragments in which the precious metal diminishes.

By this they obtain not only a *disargentation* of the lead, but also a concentration of the silver; this concentration has no limit, except in the cost of working.

The crystallization is effected by means of a battery composed of fourteen boilers. At starting (in 1860) the charge was 240 cwt.; but on account of the greater skill of the workmen, the charge has by degrees been increased to 300 cwt.

The crystallizing boilers were originally made of cast iron. A boiler containing 300 cwt. was 5 ft. 2 in. in diameter; was fitted with a cylindrical edge of 4 in., and with a tappet an inch high, in which the top of the boiler was placed.

To suspend the boilers four ears, or handles, are arranged at a distance of 1 ft. 2 in. from the bottom. The capacity as far as the tappet, which is 1 in. high, may be estimated at 43 cubic feet, holding at least 302 cwt. of lead.

To obviate the loss of lead and silver due to the failure of cohesion in the metal, which sometimes melts, they have for some years, and with great success, employed boilers of forged steel of 1 in. in thickness. On account of their cohesion and their durability the use of these boilers is more advantageous, in spite of the higher cost of manufacture.

The weight of a forged steel boiler holding 300 cwt. was 16 cwt., and the cost 13 thalers per cwt.; while a cast-iron boiler of the largest capacity weighs on an average 24½ cwt., and costs 3-⅓ thalers.

Each boiler adjoins a fire, with a door hermetically sealed, as well as a channel for ventilation, which twines entirely round it and communicates with a chimney 35 ft. in height.

The work of the boiler is done all on one side, the opposite side being covered with cast-iron plates as high as the top of the boiler, which establishes the heating channel without the aid of any other construction.

The fourteen boilers employed at the Frederic Foundry are numbered 1 (the boiler for the richest lead) up to 14 (the boiler of the poorest or trade lead).

The lead obtained in the reverberatory furnaces contains from 3 to 4 lbs. of silver per cwt., as well as a greater or lesser quantity of impurities, consisting principally of oxide of lead, sulphate of lead, and sub-sulphate of lead, the quantities of impurities are not sufficient of themselves to demand refining. This lead was melted in the boilers, and the temperature was only raised when a slight coloration took place on the surface; consequently the impurities were forced to the surface of the bath under the form of drosses more or less charged with lead. Coal is poured into the boiler, and the aqueous vapours produced added to the products of the distillation of the coal, setting the whole bath in motion to facilitate the departure of the drosses. These impurities, in the state of powdery matter, are withdrawn from the surface of the lead bath. During these operations the temperature is a little lowered, but it is still sufficient for the oxides to form on the surface of the bath. The drosses are successively withdrawn until the surface is completely freed from them; the operation of crystallization may then commence.

These drosses are taken off simply enough with a ladle.

The charge of a boiler being 300 cwt., the natural cooling of so huge a molten mass to the degree essential for the formation of crystals from silver, would require much time; the operation is therefore accelerated by sprinkling the surface with water.

The water is carried up in an iron tube, passing above the boilers; a tap with a rose on it, which opens and shuts easily, is placed in the middle of each boiler. This rain-like shower was invented to avoid the explosion which would have resulted from the presence of too great a volume of water at one and the same time. The cooling by means of water should be executed with the greatest precaution, and continued as long as ever the crusts of the lead melt anew at contact with the rest of the bath.

Besides the crystallization of the lead, it is essential to watch carefully that these crystals are not agglomerated in too large quantities, because they would then contain argentiferous fragments which would be delivered to the boilers as poor lead. For that reason the crust of the lead which forms on the walls of the boiler during the period of crystallization, should be scraped with care and replunged into the still hot mass, so as to obtain the formation of separate crystals.

The temperature is raised by degrees until the formation of a large number of lead crystals poor in silver, and it is essential to carefully maintain this heat because the ulterior success of the work depends entirely on it. With too low a temperature they could not prevent the adhesion of the crystals, nor, consequently, the presence of portions rich in silver; and with a temperature too elevated the formation of the crystals would entirely cease; even those already formed might redissolve in the bath. As the specific weight of crystals of lead is higher than that of alloys rich in silver, they are deposited at the bottom of the boiler, and it is necessary to plunge the scraping hooks down to the bottom to bring up the crystals and prevent their agglomeration.

The crystals are so much the greater as the lead, under treatment, is poorer in silver. On account of this circumstance, the limits in which the concentration of silver in the lead can be effected by means of crystallization, are very narrow; and it is proved that as to lead containing 2½ per cent. of silver, the separation of the crystals in a bath rich in silver can only be effected advantageously on account of the petty size of these crystals.

As soon, then, as they have obtained in the boiler a sufficient quantity of crystals, and of a proper formation, it is time to transfer the mass.

The manipulation of the emptying out is very simple, but it requires great bodily strength, for the ladle, weighing about 120 lbs., is filled with a mass of some two and a half hundredweight of lead. The new boiler is sufficiently warm to cause the crystals to melt immediately; the emptying out is continued until two-thirds of the contents of the boiler—in the state of crystals poor in silver—are transferred into the neighbouring boiler containing poor lead. The boilers being all of the same size, and marks of their holding capacity being indicated in the interior of each, the workmen readily perceive when about one-third of the charge, or 100 cwt., is left behind.

The cupellation tests are often repeated in the different baths upon fifty grammes of poor lead and ten grammes of rich lead.

The lead of ordinary commerce should not contain more than ·001 per cent., or 1 gramme of silver; if the lead under treatment contained more, a new crystallization would take place.

Following the experiments made in 1862 and 1865, we may note the purity of the trade lead produced at the Frederic Foundry. On 100 parts of lead we find :—

I. According to Professor Lowig at Breslau,

·03	Zn
·02	Fe
Total ·05	

II. According to Dr. Ziurek at Berlin,

·018	Fe

The specific gravity is from 11·37 to 11·40.

Instead of the Pattinson process—which as we said is numbered with the past—they at present employ at Friedrichs-Hütte a process propounded by Karsten in 1848. The early attempts towards it are thus described in a *Mémoire* by M. Gruner :—

"Karsten, in 1842, studied the reciprocal influence of lead upon zinc. He proved that the two metals never ally with one another, any more than lead will ally with copper. When the mixture of the two metals is preserved in a molten state in repose, the zinc comes to the surface, containing nearly 2 per cent. of lead, while the lead falls to the bottom, gathering in its turn a trace of zinc. The proportion is often only ½ per cent, but this feeble dose is enough to alter the malleability of the lead. The zinc appears to be unequally scattered, and this occasions many interruptions in the continuity, and thus compromises the tenacity of the lead sheets."

Repeating this experiment Karsten proved, after this date, that the zinc collects the silver, and that in distilling the argentiferous zinc the precious metal is not carried away. However, the learned metallurgist did not then attach any great importance to the new fact. Struck with the injurious effects that zinc might exercise upon soft lead, Karsten did not see that this same means could be usefully employed to isolate the silver.

The experiments were renewed in 1852, when they had learned that the process was applied in England and that a patent had been taken out by Mr. Parker for this very object.

The experiments were made at the Tarnowitz manufactory, by M. Lange, under the skilful direction of Karsten himself. At first they operated in a simple cast-iron chauldron properly heated. To a ton of lead, containing 1,406 grammes of silver, they mixed 5 per cent. of zinc. They stirred the bath for two hours, and left it at rest for six hours. The zinc, coming to the

surface, was taken off under the form of solid crusts, after having been set by showers of water. In it all the silver was concentrated; the ton of lead retaining only 5 grammes. To another ton of lead, containing 936 grammes, they mixed 2½ per cent. of zinc; the stirring occupied one hour, the repose four; the disargentation was still complete. When they reduced the dose of zinc to ¾ per cent., 56 grammes remained in the ton of lead.

Other experiments demonstrated that to reduce the quantity in a certain and positive manner to 5 grammes per ton, for ordinary working leads, containing from 1,000 to 1,400, we require 1½ per cent. of zinc, one hour's agitation and four hours' rest. It was moreover ascertained that the lead often retained ¾ to 1 per cent. of zinc, and this without regard to the dose of zinc—it will, indeed take as much as 4, 5, even 20 per cent. Thus the temperature is not at all influenced.

The agitation was produced mechanically, as in the Pattinson system as developed by Laveysière. For this no great effort is necessary, the two metals remaining in a fluid state, but scums are formed of oxidized drosses; the zinc especially has a tendency to oxidize and then no longer acts upon the lead. In two different ways they are able to remedy this obstacle—either by making the zinc come up, drop by drop, through the lead. or by causing the lead to descend drop by drop through the zinc. The first, and most efficacious of the two methods, appeared to Karsten as very difficult of realization. He applied the second, which had been formerly used in freeing coppery substances from silver by the *imbibition* system.

"Into a chauldron containing molten zinc they poured workable lead through an iron sieve. After three hours' rest, without any stirring, the lead was taken away, being drawn off by a cast-iron pipe. The disargentation was complete. On the same zinc they poured a new dose of lead and operated in the same way. Thus in these experiments, where the same zinc was always used, they were able to fill this zinc with as much as 25 per cent. of its weight in silver, and that without damaging or impoverishing the lead. The lower layers of the lead contained only ¼ per cent. of zinc, the upper layers about 1 per cent.

"The argentiferous zinc thus obtained was then distilled in a Silesian muffle. The silver remained with the lead which was found mixed with the zinc.

"In operating upon 200 kilogrammes of triple amalgam they obtained 120 kilogrammes of workable lead, containing 1½ per cent. of silver. This last was treated by direct cupellation. In reckoning the expense, the process of disargentation by zinc came to one-third the cost of direct cupellation. This latter cost 35fr. 50c. per ton of workable lead, without the general expenses, but reckoning the loss on the lead as 4½ per cent. This argentation by zinc came only to 10fr. 5c., or about 12fr., including the cost of the distillation of the zinc, the cupellation of the rich lead, and the wear and tear of tools and machinery. The cost of the *zincing* properly so called (*du zingage*) was composed of the following elements:—

"Labour	1.30 fr.
"Coal	3
"5 kilogr. of waste on the lead . .	2.25
"5 „ loss on the zinc . . .	1.85
"7.50 grammes of loss on the silver .	1.65
"Total	10.05

"In spite of this marked advantage, they did not then venture to adopt this new method at Tarnowitz, fearing they would not be able to properly refine the lead, they limited themselves to experimental refining, by means of a slow re-melting of the lead, with a prolonged rest. In his last analysis, however, Karsten recommended the employment of zinc, and expressed an opinion that lead would be purified by means of oxidation upon the dead-plate of a cupellation furnace."

The predictions of Karsten have been realized, and at Friedrichs-Hütte to-day the Pattinson system has been absolutely abandoned. We give an account of the operations as follows:—

The workable lead is melted in a boiler, in a mass of about 220 cwt. It then contains, on an average, 50 grammes of silver for every 50 kilogrammes.

After having taken off the drosses floating up to the surface of the bath, they add 75 kilogrammes of zinc, putting it in at the bottom of the bath, where the heat is sufficiently high to melt the zinc at once, which then, on account of the lightness of its specific gravity, rises to the upper layers of the bath.

The bath is stirred or puddled for an hour, so as to make the zinc penetrate as intimately as possible into the argentiferous lead, and force the silver to follow the zinc; after that the mass is allowed to cool, but not too quickly.

During this period of rest, the silver and a portion of the lead mount to the surface of the bath, and are taken off. They then ascertain what is the proportion of silver left in the boiler, so as to settle the weight of the second dose of zinc which has now to be added.

So again for the third dose; and, after the last gathering of the argentiferous zinc, the lead contains only ·0005, or, at most, ·0006 of silver.

This separation of the lead requires from eighteen to twenty hours, while the casting, heating, and gathering of the drosses do not take more than from eight to ten hours at most.

Submitting the scum of the zinc taken off to a temperature rather above the melting point of lead, they are able to subtract this latter metal, still containing from five to ten grammes of silver per cwt. This lead is returned to the boiler to undergo once more the same treatment.

The scum of concentrated argentiferous zinc, which forms a dry and spongy mass, has been hitherto blended with the residuum containing very little lead, and changed into rich lead, possessing from 1¾ to 2½ of silver.

The lead from which the silver has been subtracted retains as much as ·06 of lead, of which it has to be purified if they wish to sell it as lead of the first quality. Up to the present date, they have obtained this result, by plunging into the bath a piece of birch wood, freshly cut, and still preserving its sap, and by scattering on the lead a little Stassfurt salt.

When the lead has been brought to a temperature bordering on a slightly brownish red, the gases, which are formed very rapidly by the distillation of the wood, cause a bubbling and boiling in the lead, by which the fresh portions of the metal are incessantly stirred about and moved in contact with the salt.

This manipulation requires as much as thirty hours, besides oxidation in the open air. The decomposed chloride of soda yields chloruret of lead, and then chloruret of volatile zinc.

It thus forms several residues of salt containing oxide of lead, and it is necessary to again reduce it in the covered furnaces—the consumption of salt is about 1 per cent. of the lead.

On an average, 100 cwt. of lead thus treated yield:—

90·83 of trade lead.
6·99 of zinc scum.
4·15 of salt residues.

These processes of purification are to-day replaced by the Cordurié process, which is admirably described by M. Grunner.

M. Grunner, in his *Mémoire sur la Métallurgie du Plomb*, gives the following details upon this Cordurié process:—

"The process employed at the factory of Messrs. Rothschild at Havre is due to the researches of M. Cordurié, formerly a pupil of the *Ecole des Mines* at St. Etienne, and now established at Toulouse as a civil engineer. His method consists in zincing the lead by 'ascension,' as in the Pise process, and then in oxidizing the zinc at a red heat by the steam of highly heated water. The special arrangements of this method of treatment are protected by a patent. Before making them known, let us add to the general facts already quoted from Karsten a few new observations, due to M. Cordurié himself.

"When workable lead originally contains a little zinc, the same quantity of new zinc will take away more silver from it than if it were altogether pure. The antimony and the copper rise with the zinc and the silver to the surface of the lead, and this might altogether destroy the effect of the ulterior work. It is then necessary, as in the Pattinson system, to refine, at least in some proportion, the impure workable leads. M. Cordurié has proved that the lead can be freed from silver either by a repeated system of zincing, or by a single operation, which consists, firstly, in steadily stirring, warming anew, and then in cooling artificially, and so on, until the end desired is obtained. These facts confirm the observations made at Tarnowitz. It is probable, too, that it is not so much the alternatives of temperature as the prolonged rest that favours the disargentation. By keeping the lead upon the fire, currents are established; the heated lead mounts to the surface, encounters the layer of zinc, leaves all its silver in that, and then sinks to the bottom again, to give place to the hotter layers of lead, and so on.

"The success of the operation appears, therefore, especially dependent upon the period of rest, and from this point of view we can fairly ask, whether we ought to prefer one single operation to several successive zincings, always accomplished in a speedy manner, without a too prolonged period of repose.

"The lead is melted in one of the upper boilers, which are fitted with two pipes or tubes, through which they can pass the lead, now freed from silver, into one of the two lower boilers. The zinc is deposited in an iron box pierced with holes, and this box is fixed at the extremity of a vertical shaft, to which a rotatory motion is given.

The same shaft carries, above the box for zinc, an helicoidal agitator, which prolongs the course of the dropping and filtrating

zinc. The apparatus is withdrawn speedily after the complete fusion of the zinc, but the bath is again puddled, by the efforts of men's arms, for a few moments longer, and in this time the skimmers or ladles are again used. It is then left to cool, the crusts of argentiferous zinc are skimmed off, and transferred to a little vessel near. Here it is liquefied by the Pise process, so as to obtain other scums as rich in silver, and the liquid lead is returned to the boiler, where it is blended with a fresh supply of workable lead.

"As a general rule, the same lead is submitted to three successive zincings, spread out from three hours to three hours, while, according to the experiments made at Tarnowitz, one single zincing, with a rest of four hours, would seem amply to suffice.

"The total quantity of zinc for lead containing ·001 of silver is 10 kilogrammes per ton. But for lead containing more, from 15 to 20 kilogrammes are essential.

"The lead, freed from silver, flows into the lower chamber. When it is full the wrought-iron top is lowered, the lead is heated red-hot, and highly-heated steam is passed through it. The hydrogen and the excess of steam escape through a special conduit, which is connected with the chamber, where they are able to gather the oxides brought thither, which are, moreover, in a very feeble proportion.

"Iron, zinc, and even a portion of the antimony (when zinc is present), oxidize very easily; the lead is hardly attacked; but in proportion as it contains either zinc or antimony, the operation is concluded when the steam is no longer decomposed. From two to three hours are requisite for the work. When the lead is cooled, the top is lifted off; and then, on the surface of the metal, they find oxidized zinc under the form of powder; this is skimmed off with care, and the soft lead is poured off into ingot moulds.

"The rich crusts of zinced leads are treated in their turn, as soon as a sufficient quantity of them has been collected. The zinc is oxidized in the same way, and as a residue they have a workable lead, containing from 1 to 2 per cent. of silver, which is sent forward for the ordinary cupellation.

"The oxidized powders retain grains of lead.

"To gather up these, the powder coming from poor leads, and the powder coming from rich leads, are respectively treated.

"The first are washed upon an inclined table, by the action of a stream or slip of water; the grains, through their weight, remain on the table, and are either despatched to the reverberatory furnaces, or simply added to the poor lead in the lower boiler.

"The oxides collected may be classed, after they are poured off, into three lots:—

"The heaviest part, composed of oxide of lead, not at all rich in zinc. This is reduced in the reverberatory furnace.

"The average part, composed of oxide of lead and oxide of zinc, which is washed anew with the fresh powder.

"The lightest part, which can be sold as zinc-white.

"The rich oxides are sifted by means of a fine separating sieve into a stream of water. The grains and fragments which remain in this sieve are added to the rich workable lead, the oxides which are deposited in the water are treated by cold hydrochloric and at 12° B.

"The oxide of zinc is dissolved, the lead, the antimony, and the silver from chlorurets and insoluble sub-chlorurets, which are collected by decantation.

"The chlorurets of zinc are at present thrown away as worthless, but some day, no doubt, they will be utilized. As to the insoluble chlorurets, they are allowed to drop off, and then they are melted in a cast-iron chauldron. The metallic portions unite in the melting, and yield rich workable lead. The chlorurets remaining in a molten state and collected in the form of scum, are then reduced in the reverberatory furnace with a little lime and coal. The lead thus produced is almost free from silver, and is again submitted to zincing. It is mixed with ordinary workable lead, they thus, finally, obtain the ordinary trade lead, rich lead for cupellation, zinc-white, the use of which is well known, and chloruret of zinc, for which a purpose will surely soon be found.

"The soft lead is completely deprived of zinc and copper. For a long time it has been known that zinc takes out the copper from lead (the experiments of Braubach confirm the fact); but beyond this, zinc facilitates the subtraction of antimony, and steam finishes the refining process.

"At Havre I took a sample of lead poor in zinc; according to an analysis made at a testing office, it contained ·0075 of zinc; while lead purified by water steam, yield only the very feeblest trace of zinc.

"I also caused an analysis to be made of the disargented lead; the results were as follows:—

Lead, poorly granulated . . .	79
Oxides, properly so called . . .	21
	100

"And the oxides contained:—

Oxide of lead . . .	61·4
Oxide of zinc . . .	30·8

"The remainder was composed of iron, carbonic acid, &c. No antimony was found.

"The oxides coming from rich lead-zinc crusts are necessarily more impure; and for this reason they treat them by hydrochloric acid. But the most impure products decompose, under the form of metallic flakes, upon the iron top of the boiler, where the rich crusts are collected.

"Zinc, as we know, besides lead and silver, contains copper, antimony, &c. The boiling due to the stream of water incessantly projects metallic dross against the lid or cover of the boiler. They adhere there under the form of flakes, to which all the less fusible and less oxidizable metals, such as copper, antimony, &c., mixed with lead slightly zinced, are peculiarly liable. These flakes, on account of the silver contained, are added anew to the ordinary workable lead."

The silver, by whatever process it is gathered, requires to be refined.

Refining silver *en gâteau*, consists in separating the foreign metallurgical parts by means of oxidation.

In this operation they employ a little flame furnace (having a large current of air) built of fire-proof bricks and strongly bound with bands of iron.[1] The curvett is made of powdered bones mixed with a little fire-brick clay.

At the bottom of the furnace a cast iron platform 2 ft. 3 in. long, hangs freely, and the bottom is pierced with an oval opening, which can be closed by a curvett resting on the platform of a little waggon. The axis of this opening, about 1 ft. 7 in. long, is parallel with the flame-bridge, and just meets the middle of the opening used in working, which is placed opposite to the mouth of the furnace; the axis, in its smallest dimension is 1 ft. 2 in. long.

The platform of the front plate of the hearth of the refining forge is composed of an oval plate of forged iron, vertically fixed upon a solid axle-tree, which can be raised and lowered very easily by means of a simple windlass placed in the framework of the waggon.

The bottom of the working opening is 5 in. higher than the hearth platform, so that the cold air is at once admitted to the molten silver so as to cool it. The refining furnace, then, is a flame furnace with a moveable hearth.

The space in which the refining and cleansing of the silver is carried on is interiorly lined with steel plates, not only to facilitate the mobility of the waggon, but also to avoid the loss of any grains of silver.

When the paste of the curvett has been properly prepared and slightly moistened, it is pressed forcibly into an iron ring 5 in. high, the base of which is fitted with transverse rails. The surface of the curvett thus formed is rendered smooth; the drying operates at first very slowly, then by degrees in a more active manner, while all through they are careful to avoid any crevices.

After having cautiously raised the bone ashes to the surface of the curvett, they form a basin resting against the ring of the curvett, or an oval basin 1 ft. 5 in. long by 1 ft. broad, and 3 in. deep. This basin, after having been polished, is ready to receive the silver separated into proper fragments. Between the ring of the curvett and the border of the furnace there should remain a space of two inches all round.

This basin suffices for the treatment of 100 pounds, which, according to its purity, generally requires a *gâteau* of from 101 to 103 pounds of silver.

As soon as the curvett is placed perfectly horizontally upon the waggon, the silver is put into it and then the waggon is rolled into the hearth of the furnace, which is adjusted by raising the platform holding the curvett; the crank is lifted and the curvett pushed as far as the opening in the platform of the hearth, and the furnace itself is consequently closed.

The space left free between the curvett and the lower part of the hearth platform is filled with the same paste as the curvett, which prevents the cold air penetrating into the furnace; a lively fire is then kept up.

When the silver is brought to a red heat the fire is stirred about, and throughout the whole operation it is essential to maintain an elevated and always equal temperature, so as not

[1] Teichmann, already quoted.

to prolong the labour unnecessarily which would conduce to a waste of metal.

As soon as the silver is melted the bath is strongly stirred with an iron rod, having a rounded end. The lead contained in the silver oxidizes very easily and rises to the surface of the bath. This litharge resembles an oily skin ; part of it is absorbed on the borders of the bath by the mass of the curvett, another part evaporates.

They accelerate the disappearance of the litharge, especially for silver containing a large quantity of lead, by plunging into the surface of the bath some fragments of the clay paste, which have previously been used in refining, without having been tainted by the litharge.

The operation continues, they still stir the bath violently, the lead skin diminishes more and more, the polished surface of the silver appears. The particles of litharge unite together, and are conducted towards the edge of the curvett. At the end of five or six hours the silver is refined.

The fire is stopped, the mouth of the hearth, and the door for working are opened ; the temperature then lowers very rapidly until the surface of the bath becomes firm.

Having attained this, the curvett is lowered so as to allow them to exercise a greater watchfulness than when the silver was boiling. It is necessary to see that the surface does not become entirely firm and closed up, because the oxygen, set at liberty by the cooling, forms oxide of silver in the middle of the molten silver ; in this case the gases would burst the solid surface and the silver would be scattered in all directions. For this reason, as long as ever the silver boils, the surface should be kept open in several places. During the escape of the gases they are obliged to see that the bath does not spread over the edges of the curvett.

As soon as the escape of gases has entirely ceased, the *gâteau* is taken off, so as to let the metal cool at once.

The refined silver produced at the Royal Foundry is almost chemically pure.

The standard does not vary ; for one pound there are always ·999 of fine silver.

In consequence of its purity, this silver is in great demand for pharmacy and photography.

A large part of the residues of the different operations is more especially composed of oxide of lead, the reduction of which in the flame furnaces is easy enough.

The lower portions of the furnace, communicating direct with the lead and the oxides of lead, are protected by a solid mass of cinders strongly pressed together.

By this means they prevent the penetration of the lead into the walls, and the actual destruction of the walls. Beyond this, too, they obtain the further advantage of better utilizing the heat of the fire,—that is, a less expenditure in fuel,—because this mixture of cinders is a poor conductor of heat.

The floor of the furnace is slightly inclined towards the working side, and the tapping funnel, increasing in shape like a cone, is applied to the lowest place ; the throat of this funnel during the operation is closed with a plug of clay, which is pierced every time the lead flows—this flowing takes place every twelve hours.

The lead falls into a reservoir shaped like a boiler, placed immediately in front of the working side ; this reservoir also is prepared with a compact mass of cinders, bound with iron, and covered, until the moment of flowing, with a light plate.

The experiment of a cast-iron boiler was not successful ; it broke in spite of being heated beforehand ; moreover, the lead cooled there so quickly, that they had scarcely time to pour it out.

The gases escape through an opening in the middle of the top, immediately behind the working side. This opening communicates with the ventilation channel, which, in its horizontal part, is fitted with a slide to regulate the draught ; the channel then descends vertically along the length of the furnace, and joins the channel passing under the foundry floor, by means of which communication is established with the smoke tubes of the furnaces.

The chimney to which this whole system converges serves at one and the same time as an outlet for the reducing furnaces and the residue furnaces. The gases and oxides of lead which escape are obliged to traverse these channels, and there deposit their fragments of escaping metal.

The arrangement of the furnace is very simple.

As soon as the different parts of the interior furnace have been sufficiently crammed with the composition of cinders, and the furnace itself brought to a red heat, the charge of the residues from the boilers is put in through the working opening, and the bottom of the furnace is filled to about 3 inches high.

The working opening is closed, the fire stirred, and the slide of the air channel closed, so that the gases coming from the combustion of the coal may remain in the furnaces as long a time as possible.

As the residues comprise both coal and coal-dust coming from different treatments, the reduction profits from them, and the formation of lead from the rich oxides takes place without difficulty ; at the same time, the sulphates of lead in the residues are changed into oxides of lead. Here we have identically the same case as in the reduction of the lead ores. The oxide of lead being in excess, a reciprocal decomposition in lead and sulphuric acid takes place, as soon as the temperature of the furnace is sufficiently elevated.

The lead, on melting, naturally directs itself to the lowest parts of the furnace ; and as soon as the reaction ceases, they can proceed to put in a new charge of residues. Only they are careful to prevent the formation of solid masses adhering to the walls and the bottom of the furnace.

By degrees the furnace is filled with lead ; the scoriæ which come to the top should be energetically stirred from time to time, so as to allow the particles of lead to free themselves. In twelve hours 55 to 60 cwt. are reduced. The first discharge does not take place until the furnace has received from 80 to 90 cwt.

When it is time for the discharge, they at first soften the scoriæ on the surface by means of a more active fire ; the doors are opened, which immediately lowers the temperature, and the cooling takes place ; the scoriæ are broken into fragments, which are gathered with care from the lead bath, and thrown into iron waggons, to be ultimately treated in the kiln-furnaces.

As soon as the lead is freed from the scoriæ, they add about 25 cwt. of residues, and in the same way the work continues. They do not tap until there is from 55 to 60 cwt. of lead, so that the whole bottom of the furnace shall be entirely covered. The hearth is cleaned out, the fire stirred, and the reduction commences anew.

The lead purified in this way is poured into moulds, holding from 30 to 35 lbs., and then handed over to undergo the last treatment, in being freed from silver. After the tapping, samples are taken, to ascertain the proportion of silver.

Production of the Frederic Foundry during the Years 1824-1868, *and of the Paul Foundry during the Years* 1865-1868.

Years.	Total Production. Trade Lead.	Litharges.	Silver.	Money Value.	Number of Hands.
	Cwts.	*Cwts.*	*Lbs.*	*Thalers.*	
1824	8,855	8,256	614	—	—
1825	9,662	8,686	477	—	—
1826	5,944	6,832	370	—	—
1827	5,312	11,171	668	—	—
1828	5,353	12,068	661	—	—
1829	2,729	4,023	325	—	—
1830	2,578	7,446	472	—	—
1831	2,214	7,484	573	—	—
1832	2,355	8,473	750	—	—
1833	784	5,355	425	—	—
1834	7,748	4,231	701	—	—
1835	10,111	1,761	637	—	—
1836	14,293	3,078	1,020	35,570	47
1837	7,097	6,994	627	128,909	49
1838	2,489	7,374	584	92,274	47
1839	1,885	8,860	608	98,099	47
1840	3,317	7,595	700	105,344	51
1841	2,926	8,705	742	112,544	58
1842	6,765	4,557	707	104,382	54
1843	2,517	8,627	826	109,276	52
1844	2,124	7,233	646	89,157	48
1845	5,617	5,490	885	104,394	46
1846	7,116	6,912	1,057	130,531	50
1847	5,673	7,614	1,123	127,714	55
1848	7,110	4,732	1,926	131,828	50
1849	5,418	4,630	858	84,929	49
1850	9,749	2,886	1,068	102,495	48
1851	8,502	8,801	1,343	142,425	58
1852	7,946	6,990	1,168	117,486	59
1853	9,991	6,041	1,630	147,875	55
1854	5,777	5,344	1,007	109,530	55
1855	4,781	7,104	876	120,751	52
1856	1,532	9,573	1,061	111,967	49
1857	2,550	9,116	942	104,821	48
1858	2,253	11,465	920	130,222	52
1859	4,413	11,118	1,385	153,075	56
1860	8,236	14,462	1,703	201,737	66
1861	28,281	16,909	4,179	292,280	134
1862	59,454	19,243	8,031	689,620	180
1863	58,106	18,491	9,090	715,968	214
1864	61,759	19,902	9,090	759,420	221
1865 Frederic.	82,260	12,635	10,000	831,711	220
1865 Paul	28,000	—	2,200	220,000	—
1866 Frederic.	84,005	14,417	10,223	890,506	230
1866 Paul	28,573	—	2,400	233,387	40
1867 Frederic.	71,923	16,544	9,579	813,748	212
1867 Paul	29,506	—	2,550	249,711	36
1868 Frederic.	73,864	15,338	8,994	820,138	183
1868 Paul	26,267	11,596	2,983	316,812	?

In a working day of twelve hours they put in a charge of from 20 to 25 cwt. of residue every three or four hours.

Like the processes of disargentation, the working of the shaft furnaces has undergone notable changes in these latter days.

Four shaft furnaces have been built with the tops enlarged,

in the manner of the Rachette furnaces. After having adopted blast pipes, with a continuous circulation of water, they have for some time now put in the charge horizontally, instead of piling it up, as formerly, like columns by the side of the fuel; they have also returned to the use of coke. As a precipitant (*Eisenzuschlag*) fresh scoriæ are now employed with advantage.

On account of these changes, they have prolonged the duration of a furnace from the two or three weeks of some years back, to eight weeks; have attained a more rapid method of working the furnaces, and obtained scoriæ of a greater purity.

The fusion of the slicks—the quantity, in comparison with the ores, has been considerably augmented—is facilitated by the employment of a flame furnace, 30 feet long, where a preliminary roasting is effected.

In the channel leading to the boiler, they collected, in 1868, 1500 cwt. of dust and factory smoke, which contained, on an average, 50 per cent. of lead and ·005 per cent. of silver.

The recapitulation which follows gives, up to the year 1865, the production of lead and silver in the Paul Lead and Zinc Foundry, as well as in the Frederic Foundry. We see that the production in the Frederic foundry was constantly submitted to great variations, and that formerly, on account of the then existing machinery, the chief object of manufacture lay in the production of litharge, for many years superior to that of trade lead. Starting from 1860, the production of trade lead and silver has been constantly increasing, to attain an importance which leaves all that has been formerly done very far in the rear.

The silver produced is sold to the manufacturers of Berlin, and sometimes of Vienna, &c. &c.; the lead is exported to Austria, Russia, and since some time to America, where it is highly valued on account of its purity.

The lead ores, coming from the mines situated beyond the radius of the Frederic Mine, are treated at the Paul factory on account of the heirs of Giesche.

Donnersmarck-Hütte.

Donnersmarck-Hütte, which we are going to summarily sketch here, will later on be described with the full details that its truly model arrangements well deserve.

This manufactory is situated at the Zabrze Station of the Oberschlesische-Bahn, and on the limit of the reserved coal-field of Königin Louise. Donnersmarck-Hütte is, for the most part, composed of blast furnaces, but it is chiefly distinguished from the other similar establishments we have hitherto described by the fact that in these blast-furnaces several ores are treated which were for long considered as unfavourable for the production of iron.

In Silesia, in short, the beds of zinc, lead, and iron are juxtaposed and sometimes superposed in such a manner that a large quantity of iron-ore contains zinc or lead. The improvements in the blast furnaces have, then, been directed towards the solution of the following problem:—the extraction from the ore of three different metals separately in a condition fit for trade purposes. This difficult solution has necessarily required a construction more perfect and more complicated than that of the ordinary blast-furnaces.

Again, as in almost all Silesian manufactories, the coal is contiguous. The pit here is called the Concordia, and in the statistics of M. Labarth it is written down for an annual production of 243,984 tons; a little distance off we find a manufactory of fire-bricks and furnace-pieces.

The entrance to the pit-shaft is placed below the level of the blast-furnaces, as well as below the coke ovens, so as to profit from all the different flames in the various necessary movements.

Two engines of 400 horse-power raise the water from the pit, and distribute it throughout the manufactory, where it is intelligently utilized; the coke, destined to reduce the ore, is prepared in Appolt furnaces, the gases from which, far from being wasted, are preciously collected and brought to heat the boilers of the steam engines, both those for the coal pit and those for the blast.

Easily changed from above by means of a system of rails and little waggons, the Appolt furnaces are readily discharged below, thanks to the slight obliquity of the walls, and the coke falls into a little waggon where it is immediately drenched by a shower of water, supplied by two pipes perforated with holes.

The drenched coke is at once loaded in the waggons in which it is carried on to the platform of the blast-furnaces. The limestone and the charge of ore are elevated to the platform by a little steam engine.

Count Henckel is the owner of several iron-ore workings which furnish large quantities. This ore is treated at Falva-Hütte and Donnermarck-Hütte; he also purchases considerable quantities of ores containing zinc and lead from the other establishments which are not able to turn them to such profitable use as the Zabrze manufactory, so admirably conducted by M. Schmieder, the chief director of Count Guido Henckel's metallurgical industries. The ore comes either by the numerous lines of the Cercle railway or by the country roads, which are crowded with those four-wheeled carts we described above.

Except a few important agglomerations in which the work is mechanically executed, the iron-ore is almost always scattered in little veins; thus the country-side is covered with small hillocks, surmounted by a large wooden cylinder having a handle at each end by which two women draw up the rope attached to the ore-basket. As the ore is always extracted a very little distance from the surface, the efforts of the two women are sufficient for the traction.

The flames of the Donnersmarck-Hütte blast furnaces do not burn in the open air, but the mouth of the furnace is closed by a large conical covering, which is raised by means of chains after the charge has first been poured into the curvett funnel. The moment the covering is lifted the charge is precipitated into the mouth of the furnace, which is almost instantaneously reclosed by the immediate descent of the covering. The blast furnace being thus shut, all the gases produced by the combustion of the coke and the disoxidation of the iron escape by large pipes placed in the upper wall of the furnace-mouth, and, traversing a series of channels arranged for that purpose, they there leave all the zinc they brought with them; they also serve to warm the wind coming through the blast pipes, so that it does not come into the blast furnaces cold, and at last these inflammable gases are conducted under the boilers, where their combustion terminates.

By these arrangements, either in the Appolt furnaces or in the blast furnaces, the cost of fuel for the steam engines, both for the pit and the blast is totally suppressed, and the gases formerly wasted are utilized with the strictest economy.

With a like idea of economy they endeavour to gather the lead; for that purpose they utilize the density of the metal which draws it down to the lower part of the bath produced by the accumulation of the iron, so that the bath filling the bottom of the furnace is composed in the following manner:—the upper portion of slag, the middle portion of molten iron, the lower portion of lead.

By incompletely joining the bricks which form the bottom upon which the blast-furnace stands, the lead—which they are careful to re-heat so as to keep it in a liquid state—filtrates through the interstices of the brickwork and flows into a strongly built corridor, arranged under the blast furnaces; there we saw the lead spread out in long stalactites containing silver too, which latter is subtracted by the ordinary processes.

The Donnersmarck-Hütte slag is, for the most part, utilized in the manufacture of that *Schlacke* which serves as macadam on the roads through the metallurgical district of Benthen. To render the vitrified substance suitable for paving, it is poured into a cavity arranged for that purpose, and there left to cool slowly under a coating of sand. The rest of the slag being only a nuisance in the manufactory, and having to be transported elsewhere, is gathered in moulds, where it is formed into regular cakes easily moved into the waggons; while in blast furnaces generally this substance, scattered about in great irregular lumps, is always extremely difficult to handle. Count Henckel has added to his blast furnaces a smelting foundry, and also a bronze foundry destined to the special manufacture of mining machinery; but beyond this, other objects of daily use are cast there, such as hot-water heating apparatuses and similar products.

The methodical arrangements of Donnersmark-Hütte have not only done away with the expense of fuel, but have even reduced the number of workmen for a production relatively much greater, and have also given to modern industry notable quantities of precious metals.

The Russian Frontier.

The proprietor of Donnersmarck-Hütte, who had taken us round on our inspection of this fine establishment, was going to start the next morning to visit, near Czentochaw, in Poland, a celebrated Catholic shrine, from whence started the last insurrection, a large territory that he had colonized, and on which he had already erected several foundries, saw mills, and other interesting manufactories.

He proposed that we should accompany him, if we did not fear to trust ourselves in a country considered by Frenchmen as more than slightly uncivilised. We seized with avidity this opportunity of getting rid of several false ideas; and then looking at the map we saw that a railway, going from Cracow to Warsaw, had a station at Czentochaw, and then passed a few kilometres from Klobucko, the chief place of the canton we were going to visit; and this fact very much reassured us. Newspapers and books had formerly entertained us with the impenetrable forests, and pathless deserts of the frontier country; but the moment that a

railway passes through the virgin forest, the desert undergoes a singular modification—especially with the aid of the money and intelligence of the new German proprietors.

This mixture of the last traces of barbarism and an extreme civilization, produces the most singular effects; as long as we remained upon the German territory we travelled in a handsome chariot with very low sides, as the last fashion required, rapidly drawn by four magnificent trotters driven "four-in-hand." The bright varnish of the carriage, the copper and steel on the harnesses, glittered again beneath the sun, on a road the smoothness and levelness of which were not surpassed by the alleys in the Bois de Boulogne. On each side of a way bordered with trees, stretched beautiful prairies fringed with clumps of wood and vast fields of rye—the national corn of northern Germany, alternating with long rows of potatoes whose elevated tops indicated by their ripe greenness the richness of the soil and the perfection of their cultivation.

The crops becoming less and less abundant, the trees closer and closer, soon showed us that civilization was disappearing and Nature retaking her rights. To our left appeared a post obliquely painted with stripes of black and white; in front and to our right a thick board seemed at first to have the same zebra colours; but when we approached closer we noticed that the transverse black bars were picked out with a tiny thread of orange. Between these two posts there ran a little sandy road separating two pine forests, exactly similar in their uprightness and their beautiful proportions; but the orange-coloured thread, invisible two metres off to any one shortsighted, indicated, nevertheless, that Germany lay on one side, and Russia on the other.

We will leave those who know the two countries to develop the political, social and economical consequences of the fact affirmed by this orange thread; and we will confine ourselves to describing, impartially and photographically, that which we saw, without blame and without eulogy; for, according to our thinking, there is in ignorant barbarism a touching modesty which is more than an excuse, often indeed it has a veritable charm; an extreme civilization is a force sometimes very harsh, which interest, the ordinary motive power, well knows how to load with fulsome compliments.

The little road we followed serves as a line of demarcation for the two countries. Thus, at each stage the black and white poles to our left, the black, white, and orange poles to our right, were frequent enough; scarcely had we passed the second, when we saw rising over the right border in a clearing of the forest a block-house built of trunks of trees and surrounded with a little garden; from the door a man advanced without his weapons—pale, yellow-skinned, a thorough type of the Tartar race. His uniform, of a deep olive-green, had something massive and heavy about it, which was far from resembling the fine cloth and elegant cut of the Prussian and Austrian uniforms. He saluted us in military fashion, and looked upon us indifferently enough; but two little yellow dogs, doubtlessly trained to pursue smugglers, followed us for several kilometres, not barking like dogs, but squeaking like foxes.

Some hundred paces from the block-house, we saw, running through the trees, another soldier, covered with a tattered mantle, but this time armed with a musket; and from a distance it appeared to us that he was animated with the most hostile intentions. He seemed, as he ran, to be doing all he could to fix on the end of his gun the bayonet he had just drawn from the sheath. At last he succeeded, and reached the border of the alley in time to present arms to us with the bayonet on its musket, according to the military regulations.

Every four or five kilometres we encountered one of these block-houses, and between them numerous sentinels fulfilling the functions of gendarmes and custom-house officers, for entrance to the Russian kingdom is severely interdicted to products as well as to persons, at any other point than the stations of the custom house and the police, which are established at intervals. On the Prussian side, on the contrary, during the few leagues of our journey we saw not a single guard, not a single uniform.

At the end of a few hours we reached Herby, the first line of the Russian custom house, where long great coats and metal helmets began to display themselves in respectable numbers. A little further on we came to the police station, where it was necessary to show our passports, but, thanks to friendly relations previously formed, the delay was of the shortest. The greatest bustle and animation succeeded the silence of the frontier solitudes. A broad road was covered with carts carrying planks and timber-work, and we saw, more and more, what life and activity had been created by the Silesian colony. A fanfare of horns announced that the guards were just waiting for us at the confines of the property, and this was accompanied by a little German army, whom we passed under the triumphal arches—prepared for the proprietor of the soil which he had already so mightily transformed. Comparing the rutted roads and the sorry crops of the neighbourhoods worked by the aborigines, with the new roads and the new system of cultivation, we thought that these manifestations of joy and respect had excellent motives.

The splendid vegetation, the trees as remarkable for their diameter as for their height, indicated a soil of great fertility; this forest wealth, absolutely lost formerly for want of communication, became when properly worked, and when railways reached the neighbourhood, the source of incalculable profits. Several saw-mills worked by steam-engines made wholesale work with the woods, which have an easy sale in the country, where they are used for buildings of every kind, and which for the timbers of its coal pits alone consumes a considerable quantity of sawn wood.

The most important of these saw-mills is situated on the bank of a little lake surrounded with verdure, which exactly recalls that "Glimmer-Glass," so admirably described by Cooper in his "Deerslayer." Enormous trunks are incessantly piled up as food for these machines, and are drawn by a chain up an inclined plane to the front of the hewing saw, which squares them, then on to the finer saws, which cut them into planks, and to other ingenious machines, which cut and fashion them according to the different purposes to which they are destined. One of these machines is very curious; it grooves and trims the whole length of tile-rods intended for roofing.

Although the forests which feed the saw mills appear inexhaustible, the working either in the factory or on the ground itself is executed with the strict parsimony and the minute accuracy which distinguishes and accompanies every German action.

The problem, which consists in utilizing a tree by an exact separation of its different parts into workable wood, and wood for fuel, is resolved with a truly admirable skilfulness and care; it would be impossible in the heap that is piled up for fuel purposes, to find any fragment that might be of service for any more lucrative use whatever.

Alongside of the saw-mill there stands a curious industry, and one that would obviously serve as a text for those ill-informed persons who are affected with the mania of "common-sense." As bones contain a large quantity of phosphate of lime, a substance extremely in vogue now for agricultural purposes, they thought of utilizing this powerful manure; and as it is important to scatter all improvements as uniformly as possible, it was deemed expedient to pulverise the bones, so as to manure the furrow in a just and equable manner.

For this purpose they have built a pretty little factory, planned with an intelligence and a propriety which many flour-mills might envy. The bones are at first pounded in a mortar by little wooden pestles, worked by a cam and striking in a boss; they are thus reduced into small fragments; from the mortar they are sent to the little mills similar to flour-mills. They pass the *boulange* (grain), through a bolting mill, as if it required the most careful grinding, and they put into sacks the powder that is now unctuous to the touch; all that is gravelly, and not reduced to actual "flour," is returned to the mills to be ground anew. In spite of the odour, which is unsavoury, and which teaches one something of the nature of the substance under treatment, one might believe oneself to be in a factory of alimentary products.

Looking at the bones where they lay piled up, we seemed to recognize a femur and some human tibiæ, which made us suppose that the pretty village of Blacknovia was close to several battle-fields connected with the Polish insurrections, and with other wars civil and foreign; and that the Israelites, a careful race, and one that does not like losing anything, had thought of carefully gathering, in their long sacks, the bones of the heroes, who were uselessly whitening upon the plains.

It is not, however, necessary for a professor of political economy to draw from this fact the conclusion that the people in Poland are so unfortunate that they are obliged, as in the legends of the sieges in the middle ages, to grind the bones of their ancestors to make them bread.

Blacknovia is also the seat of a foundry, still in its childhood, but which every year turns out 700,000 kilogrammes of very malleable pig-iron, which can be advantageously moulded into utensils serving the purposes of pottery; a tapping had been prepared in honour of the master, and was executed with all the *éclat* and pomp of the operation, an object of delight to persons strange to metallurgy, and which, even for the initiated, is always a beautiful spectacle.

Leaving the shed, we passed between two lines of little girls and little boys, who, under the orders of a schoolmaster in black attire, burst out lustily into a hymn of gratitude—this again was a characteristic of German civilization. Three or four years divided us from the first capture of these savage forests, and already in the middle of this desert, crossed by paths that were

scarcely traceable, we find a school-house, children to people it, and a professor in black attire, violin in hand, to teach them reading, writing, music, order and even gratitude; and all this little world was well dressed, bearing crowns of natural flowers upon the head, and in the hand pretty bouquets carefully enveloped in paper.

Here again we acknowledged a thorough resemblance to Germany; but it was not at Blacknovia that dinner and the night's rest were to be had. It was necessary to go on to Zagorze, a castle famous in the last war of the Polish insurrection, because the former proprietor had been hanged there. We were obliged to abandon the carriage, for we wished to cross the forest, and the Polish roads were not adapted to this masterpiece of Viennese chariots. We got into a *tèlègue*, a four-wheeled carriage of wonderful solidity—a long square panier of osiers, placed directly upon the frame-work, and without springs. The seat was suspended in the inside by leathern thongs.

This manner of suspension does not preserve the traveller from heavy lateral joggings and shocks, occasioned by the ruts, tree-trunks, or other obstacles in the road, but it absolutely frees him from the trembling peculiar to carriages and carts on steel springs, the vibration of which is so wearying, and may result in such dangerous infirmities.

Two horses of a medium size drew the *tèlègue* as rapidly as the sandy road allowed. The roads over the meadows and across the fields are not worse than the French country roads; they are even infinitely better than certain roads not very far from the department of the Indre-et-Loire, which, nevertheless, passes as the Garden of France. The ground being sandy renders traction painful to the horses, but the transport is tolerably comfortable to the traveller; and if the way is too bad in the middle of the road they drive on the lower sides, and even in the neighbouring field. This will naturally disappear soon before the German colonization, thoroughly well ordered in all its actions, and naturally shocked by the over-picturesque habits of the Slaves.

When we enter the forests, even on the best little roads, the wheel soon jolts against the spreading roots of the green trees, and then one's face is sometimes bruised by the branches which a luxuriant vegetation has inopportunely thrown across the carriage way; thus the party was preceded by two men on foot beating down all exuberant obstacles with sturdy blows from their great hunting swords. From time to time we passed large clearings made by the Russians for strategical purposes. Thus movement itself became difficult, and the ground seemed to have been only prepared to admirably show off the solidity of the *tèlègue* and the skill of the driver. Wherever a tree had been torn up, the gaping hole was left open; wherever a tree had been cut down, the stump was left rising from the earth for some thirty centimetres, round which, on all sides, the roots showed their menacing shoulders. The idea of getting over such a ground in a four-wheeled carriage at first sight appeared evidently absurd. Nevertheless, the coachman managed his two horses with such skill that he often actually reached a trot, and, in spite of formidable joltings, he did not, through some mystery quite inexplicable to me, once upset us; once, indeed, I thought that the *tèlègue* was absolutely over; the left hind wheel stuck fast in the trunk of a young oak, while the two right wheels remained suspended on another trunk for at least a metre in the air. They cut down the oak, and on we passed.

The magnificence of the views left no place for fear, not even for preoccupation. Here the wood was a mixture of oak, beech, and birch, so closely pressed together that the eye could scarcely penetrate, and ten metres off a man would have been lost to sight; there, on the contrary, were gigantic pines, upright as the columns of a temple, with their branches joining in a grand and solemn roof. The ground was covered with a brown carpet, formed by the piled needles of the cones. Between the trunks, with their shadows of red and gray, circulated that blue tinted air, the natural atmosphere of fantastic divinities, and at each moment one expected to see it condense into an elf or a fay.

In places the soil had sunk, and the pines appeared to rest upon roots that spread like tripods. Gloomy mosses, weirdly-formed ants' nests, and sinister growths of one kind or another, had entwined and surrounded these naked roots, which still bravely up-bore their tree, like a giant perched upon twisted stilts.

In other places the wind from the steppes had touched the forest and left terrible traces of its passage. The pine trees were laid low, the largest lying over the smallest, and as the base of this tree, instead of throwing out its roots downwards throws them out in creeping fashion, they had, in falling, carried off huge masses of the soil itself, and held it vertically upwards. This unexpected sight contributed still further to the majestic poetry of the scene; then, all at once, underwood took the place of forest trees, well-levelled soil filled ruts and cuttings, and the carriage rolled across a carpet of wild strawberry beds.

Hour followed hour, kilometre kilometre, and the forest still seemed to spread indefinitely. At last we reached a clearing where the meadows, surrounded with woods, recalled the green verdures of the valley of Arques. The landscape, little by little, began to show traces of humanity; grey peas, buck-wheat, potatoes, and fields of rye, indicated the vicinity of dwelling-houses; the road broadened and, happily, bettered, for the shades of night were rapidly falling.

The night had quite come when we drove through Klobucko, a village peopled almost entirely with Jews. The broad, low houses, built of the trunks of trees, had put on their holiday aspect; it was Saturday night, and the little consecrated lamps glittered through the windows. The synagogue itself, the single important building in the village, was all a sparkle; but these illuminations were nothing to those which awaited us at Zagorze, the whole park round the castle was lit up by big fires ingeniously placed. Each fire was raised about a metre from the ground upon a strong pillar, bearing a broad square plank by way of a table, the upper surface of which was covered with bricks. Upon the bricks, the dead twigs and little branches of the pine steeped in tar, burnt and shone in a bright, lively flame, and the young people kept piling up fresh supplies incessantly. A crowd gathered from all the villages and neighbouring mines filled the park; and when the carriage drew up under the porch that led to the castle door, they made the welkin ring with their glad shouts of welcome. The ground was strewn with roses which literally covered the flags of the vestibule and the long galleries we crossed, when we followed the four Jew musicians, playing most energetically a triumphal march, with a rhythm strongly marked.

This orchestra was composed of three violins and a kind of little violoncello, something like the theorbo of Saint Cecilia, or the rebec of Macabie. These instruments were played by men decorously attired in black cloth; but their hair and beards were of a glittering black that scarcely allowed us to notice their olive cheeks and little deep-set eyes that shone with a remarkable intelligence. During all dinner time they continued to play dance music with a wonderful feeling and time, sometimes unfortunately interrupted by scraps from operas, the names of which it was very necessary to first ascertain before one could recognize the changes they had undergone in their journey from Milan, through Vienna to Cracow, from Cracow to Czentochaw, and from Czentochaw to Zagorze.

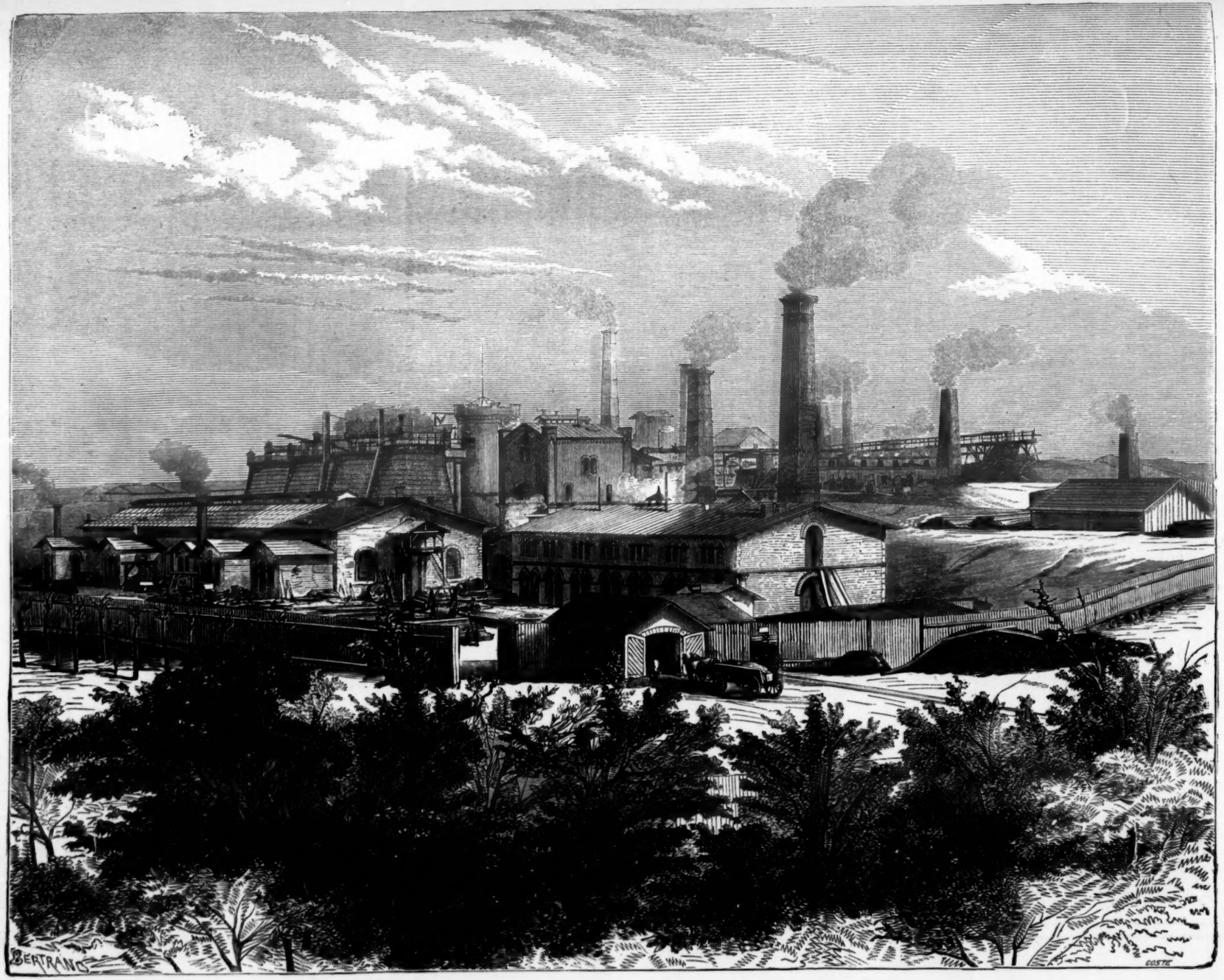
When we quitted the table they recommenced the same march furiously, and preceded us anew as we descended into the park, where the crowd had become densely packed. The appearance of any crowd is always a frightful thing; we speak of the waves of the crowd, and we are right; for nothing bears a closer resemblance to the terrible and irrevocable impression caused by the ocean; we feel truly for how little our individuality goes when we fall into the midsts of thousands of our fellows, pressing one against the other, without any possible order or restraint.

Even when this crowd is composed of well-dressed Parisians going to see the fireworks; when we speak the same language and know that a little distance off we shall find a system of police and a good regular army; we are not altogether reassured; and, surely, our feelings must be stronger still when this crowd is formed by long-bearded men, with grey garments slightly tattered, covered with turned sheep-skins, and by women dressed in shawls and fringed petticoats that plainly exhibit their naked legs and feet.

We had just contemplated the hook on the wall above the door, to which this same crowd had some years before hanged the preceding proprietor. Happily their looks to-night were rather curious than savage, and they became extremely merry when the four musicians were installed on an elevation in the middle of a clearing, and then they began to dance waltzes and polkas that were kept up the whole night long without cessation.

We slept little, for this Jewish music was always ringing in our ears, and we awoke several times to think that these amiable vassals would be all the better for a dozen German guards, and that there were many hooks still left on the castle walls. On the morrow at daybreak we arose, and our first steps in the gallery were greeted with a recommencement of the triumphal march, and it was with difficulty we escaped the violin players in order to visit the surrounding environs.

Zagorze is a large and comfortable building, the architecture of which has nothing monumental about it; long galleries, huge chambers, cellars, granaries, and vast public rooms are well suited to the dwelling of a proprietor who lives upon his estates and manages all their industries. The ground around it seems to be exceptionally fertile, and the vegetation is as thick as it is high. A veritable Norman pasturage, with its apple trees; an orchard, as if from the suburbs of Paris, with its plum and apricot and cherry trees, recalled not France only, but especially the borders of the capital, where it was evident that one of the former owners of the castle must once have resided.



DONNERSMARCK-HÜTTE.

Further on, the fields showed fine vigorous crops, equal throughout, an especially certain sign of an excellent cultivation. The best farms of the Brie and the Beauce could alone give any idea of this regularity of vegetation. It is true that nothing was spared, neither draining nor manure nor labour. Beasts from the best herds, with skins sleek and smooth and full and tight—stretched with fat, were housed and cared for with attention and precautions that would astonish most French farmers.

It is true that the example set by the Germans has not yet been followed by the natives. The rye, short, thin and stunted lets us see in the fields belonging to them a soil compact and pressed down without aëration and without life. The lean cows, which an urchin, mounted on a still leaner horse, drives before him to an exhausted pasturage, show their scraggy bones beneath their mangy thick skins.

There is nothing more painful to us than the misery of animals. Man, in the worst of all extremes has always before him, as a possibility, flight or revolt or violence, or even suicide. But the poor beast with his matted hair, his dull eye, his exhausted strength, who slowly drags himself over the ungrateful ground is forced to wait, melancholy and resigned, until his master is pleased to put an end to his misery.

Soon, perhaps, with the increase of wages, and the good example and instruction spread around by the new owners, well-being may become naturalized in Poland—even for beasts.

After a hasty visit to the farming lands round Zagorze, a visit executed in the *télèque*, at a quick trot and going across the fields without taking the ditches and furrows into any account, we started for Blacknovia, where they were going with all due solemnity to lay the first stone of a building, important always in the works of all countries, that is to say the house of M. *le général directeur* of the foundries, the saw mills and the other Blacknovian manufactories.

The Russian authorities, civil and military, and the Catholic clergy, were assembled in great pomp, while the four violinists were already at their posts, again beginning with the old fury to pour out the strains of their triumphal march as soon as ever they perceived their lord's carriage approach.

The building which occasioned this solemnity, was a massive brick construction, already as high as the first story, the stone to be laid—and blest—was quite ready; the priest, whose rank in the hierarchy we did not ascertain, but who from the richness of his attire must have been at least a bishop, mounted the prepared scaffold, and began the customary prayers. Round him were grouped the Russian civil authorities, in grey trousers, blue coats, and gold buttons, and caps with broad blue bands.

One of these functionaries was a Pole who knew Paris and France, the language of which he spoke with ease. He received me with great demonstration of sympathy, and spoke to me warmly of his country, the precarious situation of which he deplored.

The Russian officers, in green great-coats with red and gold ornaments, had a capital bearing in their regulation uniform, they were as courteous to me as educated well polished men could be, but slightly surprised by the unexpected presence of a stranger; they spoke the French of your true Parisians and expressed their astonishment at receiving a Frenchman at Blacknovia; for my part I might have replied with the well-known *mot* of the Venetian ambassador at the court of France.

The rest of the assembly were far from having the Polish character sostrongly expressed as the Zagorze dancers; the dignitaries of the German management were, some in evening dress, others in frock coats and great coats; the women in crinolines and the fashionable long skirts. Excepting the rare official uniforms, one might have as readily believed oneself at Meudon, or at Courbevoie, as at Blacknovia.

It is true that at the first speech the illusion was quickly dissipated; when they had placed under the stone a commemorative medal, where my name accompanied the illustrious local personages present, each of us struck a few blows with the hammer, according to the usual rites; there was then an interchange between the Germans and the Russians of compliments most flattering to the two nationalities, and it was solemnly agreed by both parties, amidst the applause of the crowd, that Germany and Russia, Russia and Germany, were the two greatest nations in the world.

We would gladly have claimed a little niche for France, if our travelling dress, altogether wanting in dignity, had not held us fixed to our place on the ground; besides, the task would have been difficult enough, and we might have chanced to utter some folly which might have offended one at least of three elements present. We were obliged, as our only protestation, to keep a steady smile on our countenance, and in a short mental oration we wished our France a portion of the prosperity, glory and welfare that our neighbours were retaining so egotistically for their respective countries.

An improvised ball naturally succeeded the religious ceremony, and the indefatigable quartette distinguished themselves anew. We thought them thoroughly occupied in executing polkas and waltzes, when, trying to hide our departure amid the acclamations of the crowd, we found them ready as ever upon the road to the carriage, and pursuing us for a last time with their triumphal march, become for this occasion plaintive and almost despairing.

After throwing a last look upon the little lake, we entered anew into the grand silence of the forest. Before reaching Herby the carriage stopped before a hermitage of carved wood, the door and façade of which were decorated with branches and flowers—a veritable opera-comique hermitage, so new was it and so proper; from it issued a hermit, dressed in a black pilgrim's gown of some brilliant stuff resembling silk. He addressed us in Polish; we could not comprehend a word of the speech, but the expression of it was full of nobleness and unction; long hair, and a full beard beginning to be streaked with silver, surrounded his pale face, animated with a fine and pleasant smile. His little eyes, grey and brilliant, fastened themselves with an inexpressable tenderness and gratitude upon the new master, who had brought to his poor fellow-countrymen the benefits of work and order.

A little further down, at the junction of two roads, rose a calvary resting-place, round which the pilgrims on the way to Czentochaw were halting; the women displayed as always their bare feet and naked legs; they wore a short petticoat of a brown colour, and on the head a shawl fastened under the chin, like the holy women in the pictures of the middle ages.

The men, in long grey or blue great coats, had in general long hair covered with a little low black cap, with its borders turned up. From their shoulders hung, by way of shoulder belt, a long white bag, bulging out in the middle with the provisions or articles of change in it, the two ends being knotted together across the breast.

Was it fatigue or was it piety? but certainly the drooping shoulders, the head half bent and weary, the prostration of the whole body, gave the pilgrims the touching appearance of that ecstatic sinking, so well rendered by Tintoretto in the Crucifixion of Our Saviour.

On the road we encountered groups of pilgrims preceded by banners and singing canticles; they were going to Czentochaw, the church of which was visible afar off in the horizon, its nave at least as high as that of the cathedral of Chartres.

Before leaving the Russian empire we were obliged to stop at the custom-house and the police-station, to have our papers vised anew, then, after exchanging a few civil words with the chiefs and giving some money to the soldiers, we were permitted to re-enter Germany.

At Lissau we passed before the Prussian custom-house, a large square building, looking like a school; on the threshold we were saluted by an old gentleman in spectacles, who bore much resemblance to a magistrate—he was the sole defender of the German frontier—not a gendarme, not even a custom-house official.

Workmen's Institutions.

Just as we were closing our study upon Upper Silesia, we received an excellent report entitled "Beitrag zur Geschichte des Schlesischen Bergbaues in den letzen hundert Jahren." From this we translate the following passage, which will be of interest to economists:—

At the moment when Silesia was first governed by the administrative system of Prussia, there were but very few miners in this province; there was an especial want of active superintendents, and a new supply of workmen was necessary. The formation of a colony became then a vital question as regarded the prosperity of the Silesian mines, and they were only able to solve it by granting to the workmen from other districts favours that were altogether peculiar.

Upon the model of the ordonnances granted in the year 1767 in favour of the Westphalia miners, and also upon those which the mining laws of the 5th June, 1767, took for their base, they granted on 3rd December, 1769, in favour of the province of Silesia and the Margravine of Glatz, a general privilege, followed by instructions for the organization and establishment of a Miners' Fund.

By general privilege, they granted to the workmen in the mines and foundries, after they had taken the oath of fidelity and obedience, and had been entered on the register of the corporation, that which follows, to them and to their descendants.

The right of free choice of dwelling in the provinces; exemption for themselves and their children from military service; freedom from all and every communal charge; the privileged

jurisdiction of the Upper Tribunal of Mines for all differences concerning mines and miners among themselves; free rations for miners on the tramp; payment, at the expense of the mine owners, of the wages of the sick for two months for mines working at a profit, and for four weeks for mines working at a loss; admission into the society of the corporation.

Excepting these two last privileges, which, on account of other laws upon the organization of the Miners' Association, have received another mode of goverment, the other advantages have fallen, and rightly, into disuse; in brief, the miners to-day lay no claim to the enjoyment of special privileges, the more so because the whole system of corporations has been suppressed; these favours, at the time when the corporation of miners obtained them, were indispensable to attract the miners from distant countries, to make the corporation feel its independence, and to endow them with the sentiments of solidarity essential in reviving the industry of mining.

As to the institution of the association, the ordonnance on mines dated the 5th June, 1769, had already made arrangements, by fixing the receipts for the supply of the fund, and by the advantages this accorded to the members of the association.

Firstly, the ordonnance upon mines arranged in ch. xxxi. s. 1, that two shares of each mine or $\frac{1}{64}$ should be handed over entire to the profit account of the fund to assist the members of the corporation; further on, in ch. lxxvii. s. 4, it states that all the fines resulting from delay in payment after sentence had been passed, and, in ch. lxxxv., that all the fines, in general imposed by superior office of the mines, shall pass into the miners' fund.

On the other hand, according to ch. lxxviii. s. 1, of the ordonnance of mines, the miners who fall sick without any fault of their own, while working in a mine, may draw upon the funds of the syndicates of respective mines, during eight weeks for a mine working at a profit, and during four weeks for a mine working at a loss, for the same wages they were receiving before sickness. The same favour, according to s. 2, was granted to the widows and heirs of the miners in case of accidents undergone while working in the mines; lastly, for miners without private resources, the fund bears the expense of burial (s. 2 & 5).

An ordonnance, dated 20th November, 1769, disposed of the organization, and governed the management of a miners' fund in the Duchy of Silesia and the Margravine of Glatz. According to these arrangements, the administration returned to the director of the office of mines, and the sub-director kept the miners' fund; this latter watched the payment and entry of the sums due by the different mines, which the master owners were obliged to pay in at the end of each three months; he also watched the return of a small subscription from miners, which formed a very little portion of the wages earned.

This fund supported the expenses incurred by illness, granted to indigent workmen, incapable of labour, a monthly allowance, according to the judgment of the office of mines, and according to the condition of the fund; after the decease of a miner, it granted to the widow a monthly allowance, more or less according to the circumstances of the case, and supported the children until they were grown up.

According to the ordonnance, the office of mines could raise an extraordinary levy, and obtain the approbation of the general direction; on the other hand, the wages of sick miners and the cost of burial, could be paid direct by the office of mines.

The control of the fund was exercised by the two oldest miners; one of whom at least was obliged to be present at every payment.

In other districts, on the contrary, the body of iron workers took part in the association, with the exception of those working in the private iron foundries not under the direction of the office of mines.

Among the establishments which took direct part in the association we must chiefly instance the blast-furnaces belonging to the State and the zinc foundries; the former still take part in the association, while the zinc foundries withdrew in consequence of the Congress of Feb. 22, 1829, which declined the independence of the zinc manufactories; consequently the zinc foundries have been discharged from all levies and contributions to the Miners' Fund, and, on the other hand, have renounced all claims upon the abovesaid Fund.

With the prosperity of the mines the number of members forming the association has increased, and the demands have consequently augmented; so that a reorganization as to the principal bases of the statutes became indispensable. The instructions of Nov. 20, 1769, have been replaced by those of Jan. 1, 1811.

A common fund, including the whole district of the Superior Office of Mines, has been formed; separate funds in the different circles have been suppressed; the subscriptions and the payments of grants have been confided to the heads of the mines and the manufactories.

The special officials of the association are,—the secretary, the cashier, and one controller, as well as the miners chosen by each circle; these last were nominated by all the members of the association; that is to say, they proposed three different persons among whom the direction of the mines and the foundries, subject to the Superior Office of Mines, elected the most deserving.

According to this ordonnance the receipts included:—

I. On the part of the workmen, the *tronc* (or charity) money—the proceeds of one day's labour at eight hours, per month—the right of inscription after being received into the association, the payment of a week's wages upon commencing work in the mines, the forfeit of half a week's upon increase of wages, all the fines, plus so much per cent. upon the nomination and promotion of the employés, including those in the Upper Office of the Mines.

II. On the part of the mine owners, four shares in the free mines, two of which to be specially devoted to the support of churches and schools (these two have latterly been separately administered), voluntary gifts from the mine owners upon obtaining any concession, and those given by contractors upon the conclusion of their contracts, the cession of the old meeting places, and, finally, the tenth part in cash of any saving in material effected in the royal mines.

According to the ordonnance, the fund granted allowances to the sick in the following manner: if the sick person belonged to a mine working at a profit, or to a State mine, the owners or officials paid at their own cost his ordinary wages for the period of two months; if, on the contrary, he belonged to a mine working at a loss, the owner only paid these wages for one month, and it was only after the lapse of this period that the fund of the association was called upon to aid the sick persons. The allowance was equal to that which the miners received before sickness; moreover, the funds of the association granted monthly aid for the education of the children whose fathers were invalided or deceased; it undertook the cost of burial, gave the miners' children a free primary education, defraying not only the cost of education itself, but that of school books and school articles.

These arrangements, with very few changes, were preserved until the decree of April 10, 1854, concerning the reunion in association of the workers in mines, foundries, and salt mines.

This decree regulates the minimum of duties to be carried out by the association in regard to those members having the greatest claim on it, which are:—

Physic and medical attendance gratis in case of sickness, wages to a sick person during the whole of his illness; life pension to those incapacitated for labour, if that incapacity has not been caused by the negligence of the workman himself; participation in the cost of the burial of a miner; assistance to the widows; aid and education to the children of miners deceased or invalid.

As to the less favoured members, they were granted medical attendance and physic gratis, allowance to the sick, and participation in cost of burial.

According to this decree, the funds had to be furnished by subscriptions from the workmen in proportion to their wages, as well as by subvention on the part of the owners, these subventions to be at least equal—no matter what the profit or loss of the establishment—to one-half the total subscription of the workmen; consequently the obligation of reserving two shares in the free mines on account of the fund of the association is suppressed, so that now mines working at a loss participate equally in the charges.

The new receipts were fixed by new statutes which had to be approved by a law.

The most important change effected by this new law consisted in the nomination of the administration of the fund.

This has been entrusted to a direction freely elected by the members of the association and the owners of the establishments; the intervention of the office of mines is limited to watching over the strict observance of the statutes; the officials and the doctors are nominated by the direction, and the miners elected are entrusted with the control.

A much more important consequence of this law has been the separation of the single association for the whole province into two societies—one for Upper Silesia and another for Lower Silesia.

As soon as the entire direction of the society was put into the hands of the interested parties themselves, they necessarily and justly felt some scruples at maintaining one single society, because the interests of the miners and owners of Lower Silesia bore no resemblance at all to those of Upper Silesia.

They preferred then to found two separate associations.

The association of Upper Silesia comprises all the mines of the district formerly dependent upon the office of mines at Tarnowitz; this district is limited by the administrative circle of

Œppeln, as well as by the manufactories belonging to the State (the foundries Kœnig, Gleiwitz, Malapane, and Kreuzburg, and the establishments of Rybuik, which have since become private property).

The Association of Low Silesia is formed out of the old mining district of Waldenburg, limited by the administrative circle of Breslau and Leignitz in Silesia, and by the provinces of Posen and Prussia.

In Low Silesia they adopted the principle of conciliating the heterogeneous elements, and consequently formed only a single society, comprising the establishments producing only coal or metal, as well as the manganese mines of Braun-Kohl, situated in the Oberlausitz and in the provinces of Posen and Prussia. This reunion has given rise, even to this day, to complaints of all kinds, not only because the long distances hinder the administration from working regularly, but still more because the organization of these latter mines differs entirely from that of coal and metal mines; in the same manner the mode of life among the workmen is completely different.

Alongside of these two great associations they have formed in the lordship of Pless, a special society. This association cannot take part in Upper Silesia because the mines situated in that lordship are not under the government of the Office of Mines.

For the manganese establishments of alum, and iron, situated in the lordship of Muskau and belonging to S. A. R. Prince Frederick of the Low Countries, there already existed a Miners' Association before the decrees of April 10, 1854.

It was not easy to divide the old possessions of the important association of Silesia between the two new branches of Upper and Lower Silesia.

After long negotiations, and for want of any other more equitable mode of settlement, they adopted as a basis the existing numbers in each division. At the end of 1856 the position was as follows :—

2,531 members of the Association of Lower Silesia, and 7,597 members of that of Upper Silesia, or $\frac{1}{4}$ and $\frac{3}{4}$ of the total number of miners; it was then settled that the property, amounting after liquidation to the round sum of 433,149 thalers should be divided between the new associations in the above proportions; so that the association of Lower Silesia received 108,287 thalers, and that of Upper Silesia 324,862 thalers—the whole in deeds, settlements, or cash sterling, while the buildings serving as hospitals, or for other purposes, were allotted to one or other of the associations according to the position they occupied.

This division into two of the chief associations was effected as soon as the statutes had been, conformably to law, duly signed by the Minister of Commerce.

The two associations obtained their statutes upon 7th December, 1856, and from the 1st January, 1857, one of the two societies began its work at Tarnowitz.

On the 6th October, 1859, the statutes of the association of Upper Silesia obtained an additional Act, and on the 1st January, 1863, they were altogether recast. These new statutes to agree with the disposition of the general law of the mines, dated 24th June, 1865, including in its fifth chapter many miners' associations, have been replaced by those of the 28th February, 1867.

The statutes of this Association of Lower Silesia, of December 7, 1859, have also undergone several modifications, and were replaced on December 27, 1866, by new statutes agreeing with the general laws of the mines.

The association for the whole of the establishments situated in the lordship of Muskau began work January 1, 1859, in virtue of the statutes dated November 1, 1858; these statutes in their turn have several times been modified, and have in fact been recast so as to be more fully in accord with the general laws of the mines.

We should occupy too much space, if we tried to trace the different arrangements of the statutes, and this would be still more the case with the organizations on the part of owners and men, as well as in the advantages resting upon the bases of the laws of April 10, 1854, and of June 24, 1865.

At the time when the fund of the Miners' Association was administered by the Upper Office of Mines, it held the profits of two shares in each mine destined, according to ch. xxxi. s. i. of the ordonnance upon mines, to the support of churches and schools; with this money the fund not only charged itself with giving indemnities for the construction of schools and churches, but it further defrayed the cost of schooling for the children of members, and procured them all possible means of self-instruction.

After this separation the associations of Lower Silesia and Upper Silesia undertook the duty, in addition to putting the statutes of January 1, 1857, into force, of defraying the cost of classes and education, either in whole or in part, and of reserving the funds which were by degrees formed from the accumulation of the mine shares, to grant to the expense of education, support of schools and churches that which would not have been paid by the associated fund.

The association of Upper Silesia has to this day maintained the payment of school expenses; it has done its duty to the full in ameliorating the condition of the young people, while the association of Lower Silesia disembarrassed itself of this charge as soon as the statutes of January 1, 1867, were put into force, leaving everything to be paid from the monies resulting from the two shares in the mines.

Among the arrangements adopted to sustain the moral well-being of this working population of Upper Silesia we must mention the following :—

All the workshops belonging to the State are provided with schools; those of the manufactories of Kœnig, Malapane, Kreuzburg and Frederick were erected at the same time as the establishments; for the workmen who came from a distance, being chiefly German Protestants, would have had no other facilities for giving instruction to their children. The Catholic schools, where for the most part they teach only Polish, are some long distance from the workshops. These schools were originally supported by the fund of the association, and, later on, by the profits coming from the shares in the free mines; but since 1860 they have been exclusively subventioned by the funds of each establishment.

On account of the increasing number of pupils and the progress of instruction, these schools have by degrees been enlarged and improved; they suffice for the development of the instruction of youth.

One of the most important among these schools exists at the Lipine foundry, near Morgenroth, belonging to the Society of Mines and Zinc Foundries of Silesia.

Besides these primary schools there exist Sunday classes, intended to preserve and maintain the knowledge acquired by the young people who have left school. In some establishments these Sunday schools are changed into finishing schools, where the young workmen have an opportunity of strengthening their studies and preparing themselves for the situations of foremen.

There are also schools for progressive teaching, worked in an independent manner, as, for example, at the Kœnig foundry.

We should, too, quote the mining schools established at Tarnowitz and at Waldenburg, and which are actually maintained by the mutual fund of the coalpits.

For the intellectual culture of the older workmen they have recently founded reading-rooms, in an experimental way, at the Kœnig mine and at Malapane; but hitherto the result has not been very appreciable.

Very important results have been experienced in the Independent Industrial Schools, where the daughters of the miners and the workmen receive sewing lessons, and where they are prepared for their future duties as good housewives.

The cost of these schools, when they are defrayed by the mine owners themselves, are generally supported by the funds coming from the shares in the free mines.

There are also organizations for procuring personal effects and household utensils for the respectable widows of miners.

For this purpose they have founded in many places supply associations; for example, at the foundries of Kœnig, Lipine, Zabrze, Hohenlohe, Rosdzin, &c.

These societies have no particular features, and are, on the contrary, organized upon the model of all the other known supply associations.

They nevertheless do merit a special mention.

The supply associations, as well as the loan societies, which were formerly established in a very restricted manner, rendering the workmen independent of the shopkeepers, accustom them to pay for their goods on the spot, and consequently to regulate their household expenditure; finally, the workmen avoid the seizure of their wages, or deductions from the wages of the future.

Since the mines have been worked, especially in Upper Silesia, where a considerable increase in the working population took place, the question of lodgings, to attract and retain good workmen, has been of great importance.

In a country as little peopled as Upper Silesia formerly was, when a considerable increase in the working population occurs, the insufficiency of lodgings can only be modified by constant efforts. Even to-day it is the same, for the increase is continual, and in proportions which it is impossible to foresee.

In Lower Silesia this difficulty was less sensible, because the numerous villages built in the proximity of the mines furnished the workmen with means of lodging. But here also the need of taking steps became urgent when the production of the mines had considerably increased, on account of the opening of the railway from Breslau to Freiburg.

Thus, in the neighbourhood of Waldenburg, Prince de Pless, owner of the Fürstenstein mines, built, at a cost of 30,000 thalers,

four workmen's houses, containing forty-eight lodgings; each lodging is let, at from fifteen to twenty thalers, to families of miners.

The syndicate of the Weisstein mine gave grants in 1857 to the owners of the land near, for the construction of miners' lodgings; consequently in two years they erected in the village of Weisstein twenty new houses, with 150 lodgings, for which the syndicate of the mine paid 2,800 thalers.

The syndicate of the Glückhilf mines near Hermsdorf purchased several dwelling houses, which they let to the workmen at a very low rent; but since 1867 they have adopted a new principle. They have acquired the possession of large estates, which they parcelled out and sold in different lots to the miners at a very small price, upon the express condition of building, according to the plans furnished, houses containing four or six lodgings. For this purpose the syndicate granted advances, and a prize of 200 or 300 thalers.

In Upper Silesia strong measures were taken to procure lodgings for the workmen; as, for example, in the coal pit of Luisenglück, near Rosdzin; at mine Ferdinand, near Kottowitz; at the Godulla foundry, near Morgenroth; at the Scharlei mine, near Beuthen; at the Katharina coal-pit, near Ruda; at the Donnersmarck foundry, near Zabrze; at the Börsig manufactory, near Biskupitz.

Large and small houses have been erected by the mine owners, and are let at a low rent to the workmen. In the last ten years the principle of real property, by which the workmen can themselves in time become the proprietors of their houses, has begun to gain ground in certain quarters.

This principle has, however, only been applied for a few years to the mines and foundries belonging to the State in Upper Silesia.

At the time when an impulse was given to mining industry, that is to say, towards the end of the last century, they were obliged to bring the workmen from a distance, because the aborigines were not capable of working in the mines and foundries—were not willing, indeed, to submit to the labour. The question of lodgings was at once presented, and, to remove it, the proprietors of the establishments were themselves obliged to build houses. It was about this period that the working colonies near Malapane and Kreuzburg were created.

In succession the following were built:—in 1787, ten houses near the Frederic foundry; from 1798 to 1822, thirty-one houses, near the Kœnig foundry; in 1800, sixteen houses near Gleiwitz; and from the years 1848 to 1852, ten houses near Zabrze, on account of the Königin-Luise mine; in 1843 the Kœnig foundry purchased four properties, containing fifty-five *Morgen*, and then built eight houses.

In these seventy-nine houses there is accommodation for 339 families at a low rent; they have cost 118,893 thalers, and still belong to the different establishments.

In the interval, in 1824, the administration of the Königin-Luise mine has made the experiment of selling to the miners at a cost of 600 thalers each, to be paid in small instalments, twenty little houses, each with one lodging, which they had just acquired.

The result has been favourable. The Kœnig foundry followed their example in 1841. At this period it built, at a cost of 10,850 thalers, eighteen houses, each with two lodgings, and these lodgings were each sold to the miners at 600 thalers, payable at the rate of 36 thalers a year, until 500 had been paid, the other 100 were a mortgage, without interest, on the house, as long as it remained in the hands of a miner. In 1857, all the sums had been entirely re-imbursed.

The result has been completely satisfactory. A knot of good workmen has been formed in this manner, and workmen, more and more numerous, have come to settle in the country.

But on account of the strides that the local industries have taken, especially since 1850, a large increase in the number of workmen has become urgent. To preserve the old system of building houses at the cost of the owner of the establishments, immense capital would have become necessary, either to let them or to sell them, consequently, this system has been abandoned.

Since 1854, they have urged the workmen to build their own houses themselves; and, to this end they have given them plots of their own gratuitously, containing half a *Morgen* each, suitable to the purpose. The mutual fund of the coal pits of Upper Silesia has given advances bearing interest, and even, since 1864, advances without interest, plus a prize of 100 thalers for every house completed, the advances being repaid by monthly instalments.

This system has been applied in the Kœnig mine, as well as in the Königin-Luise mine.

There have consequently been purchased from 1854 to the end of 1868:—

On account of the Kœnig foundry about 78 Morgen of land.
On account of the Kœnig mine „ 95 „
On account of the Königin-Luise mine . . . . . „ 70 „

At a cost of more than 60,000 thalers.

These estates have been divided into lots for the construction of workmen's houses.

The workmen have built:—

Those of the Kœnig foundry . .	154	houses.
„ Kœnig mine . . .	194	„
„ Königin-Luise mine .	139	„
Total . . .	487	„

These gave shelter to 1,500 families.

To attain these results the owners have expended:—

	Advance for building without interest.	Sums paid in prizes.
Kœnig foundry . .	57,500 thalers.	15,400 thalers.
Kœnig mine . .	65,650 „	19,400 „
Kœnigin-Luise mine .	27,800 „	13,814 „
Total . .	150,950 „	48,614 „

The system has succeeded so well, that they will continue in this way for the future.

Formerly the fund of the Miners' Association, and latterly the Mutual Society of the Coal Pits, granted or do grant advances for the building of new houses or the enlargement of old ones; not only for the workmen engaged in the royal establishments, but even for the miners of Upper Silesia in general, and this consequently has contributed much to the increase of lodgings. The mutual fund for advances under 50 thalers requires no interest; for sums above 50, 4 per cent. are asked. In the same end the fund of the Miners' Association has disbursed in all 8,150 thalers; while the mutual fund has employed up to the end of 1867, 113,405 thalers.

They cannot prove any sensible loss resulting from these advances for building purposes.

The single miners, or those who leave their families in their own countries, also find shelter in these houses. To render this class of workmen independent of the workmen owning houses, the Kœnig mines erected in 1866 a dormitory to contain 100 men, where, besides a bed for each, they have all that is necessary for cooking their own food or for having it brought in.

The dormitory is constantly occupied, a proof of the great need there was for it; they are now busy in building a second one.

The Königin-Luise Mine also proposes to establish a dormitory.

We must also mention the funds in cases of decease, or rather benefit fund, formed by the Free Association among the workmen.

Societies of this kind have been founded at the Kœnig foundry, at the Kœnig mine, at the mines situated in the district of Neurode, and finally at the mines near Waldenburg.

These funds are intended to allot to the miners' families some assistance in addition to the acknowledged insufficient allowances of the Miners' Association.

This tendency is so much the more praiseworthy as generally the workmen, obliged as they are to take their share in the fund of the Association of Miners, think no further of the consequences of death or incapacity for labour.

It is among the miners of Lower Silesia especially that these societies have had a great success.

All these funds, associations, and schools work with a perfect regularity as well as many other private associations, either for business, or music, or gymnastics, or for other ends of obtaining pleasure or instruction. The feeling of solidarity and union with their fellows, which is so difficult to introduce into France, even for things the most necessary, is, in Silesia, inculcated into the child as soon as he is old enough to go to the primary school.

The father and the mother work all day in the mines, or the manufactories, or at agriculture, but the children do not run about begging on the public highways as in so many of our industrial cities; they are gathered into the schools, where they receive not instruction only, but also that moral and physical education which developes them and has given the Prussians their incontestable superiority over the people of central Europe.

Not only do the State, the circles, the towns, the private societies, favour the instruction of the young with all that is in their power, but it is a duty which the notabilities of the country confess with pleasure to contribute by their personal gifts to encourage the children in their education. In Repten Park we

took part in a review of the boys' and girls' schools of the neighbourhood—a true youthful *fête*,—when the most meritorious were rewarded with prizes and presents.

More than 1000 children, divided into squadrons, each bearing the banner of their village or corporation, and marching in rank like young soldiers, formed a square, the lads on one side and the girls on the other; they sang a grave and solemn national hymn, the melody of which recalled the chorus in the *Huguenots*.

The songs were well performed, the time perfect, and the impressions caused by these hundreds of youthful voices was extremely touching.

Several speeches and several choirs formed the moral part of the fête; then the boys began a series of marches, countermarches, sham combats, and other gymnastic exercises, very potent in the development of the body, and which have, moreover, the advantage of preparing the youths for military manœuvres. We had before us a nursery of future conscripts, very differently trained to bear the musket than are the urchins of our own villages.

Physical education, which accustoms the body to move according to uniform rules, has an equal influence upon the spirit, the thoughts and manifestations of which it regulates; this it is that gives the Prussians that pronounced national stamp, which it is impossible to mistake when it has once been noticed.

The *fête* was continued by a good breakfast for all the world, and by a distribution, to the most meritorious, of books, maps, compasses, foot rules, boxes, and other educational articles.

There were also scarf pins and gilt-studs for the boys, and for the girls ear-rings, brooches, rings, ribbons, fichus, and other toilet articles, all of which were well chosen and in very good taste.

The whole of the crowd, far from having the worn and tattered appearances which we so often regret to find in the vicinity of our own factories, had a happy and well-satisfied air, and were dressed in decent and suitable attire. With the exception of a few agricultural children, they belonged, almost all of them, to the families of miners or workmen or foremen employed in industrial pursuits; their relations, as well as a large number of the inhabitants of Tarnowitz and the neighbourhood, had come into the park to assist in the ceremony, which was terminated, like every good German rejoicing, by dances and waltzes, which were unfortunately interrupted by the rain.

This example would have sufficed to allow us to judge the actual welfare of the working classes, as well as the good relations existing between masters and pupils, owners and workmen; and this day did not a little contribute to augment the esteem and the sympathy with which the German character had inspired us.

From the time of our visit at Essen to Herr Krupp, we had already conceived a very high opinion of industrial Germany. Our readers may see from this hasty account of the power of the Silesian establishments, how strong are these *Allemeignes*, as Louis XI. used to say, and yet how little known they are in France; and still we have only spoken of the metallurgy of zinc and argentiferous lead. We have yet to describe the salt mines, the coal pits, and the manufactories occupied in working iron.

THE CUSTOMERS OF THE UNITED STATES.

THE Bureau of Statistics at Washington has issued an analysis of the exports of the principal domestic products of the United States in the financial year ending the 30th of June, 1873. The total export of wheat is valued at 51½ million dollars; and Great Britain and her Colonies took it to the value of 49,700,000 dols. Under the head of wheat flour, Great Britain and her Colonies account for eleven millions out of the nineteen exported. The British West Indian possessions take more than half of all the biscuit exported; and of the exports of Indian corn, 22¾ millions go to Great Britain and her Colonies, leaving only one million for all other countries put together. In cotton the United Kingdom take three-fourths of the entire surplus exported, heading the list with a value of 161 million dollars. Of hams and bacon, Great Britain takes 22 millions out of a total of 35 Of beef, Great Britain and her Colonies take about two millions out of a total of two and a-half millions; and of pork, three and a-half out of five millions reach the same destination. About one-half of all the butter exported goes to England and her dependencies; and out of a total export of ten and a-half millions' worth of cheese, nine and a-half are absorbed by Great Britain. In lard, Germany is the chief customer, taking a little over six millions in value, against the British consumption of five and a-half millions. Of this article Belgium takes three and Cuba two millions' worth. In tallow, England leads again, taking three millions out of a total export of seven millions. Of manufactured leather, Great Britain and her Colonies account for a little short of three millions, while Germany takes over one million of dollars in value, or about all that remains. Coming to mineral oils, the balance shifts in favour of Continental Europe. Of crude oils France takes about two millions, and Germany half a million, leaving half a million for all other countries. In refined illuminating oils, out of a total export of 34 millions, Germany leads with 11½, and Belgium comes next with five millions, a very large portion of which is, in both cases, distributed over the Continent. Of the leaf tobacco exported, Germany takes the larger share, having received it during the last financial year to the value of six millions and a-half, but the sum of the tobacco export to all the places owing allegiance to the British Crown is only a very little short of that amount. France takes two and a-half millions' worth of tobacco, Italy two millions, and Holland and Spain 1,300,000 dols. each. Coal exports experienced a considerable increase, chiefly due to the Canadian demand for over two millions, or two-thirds of the entire export. Agricultural implements, chiefly mowers and reapers, also show a remarkable increase, for which 900,000 dols. sent to Germany partly accounts. The iron exports increased from six to eight millions, and of the latter amount Cuba took one and a-half million, the Dominion of Canada a similar amount, the United States of Colombia 850,000 dols., and Germany 620,000 dols. As a general conclusion we find that wheat, Indian corn, cotton, and provisions accounted for 371,500,000 dols., or 55 per cent. of the total domestic exports for the year, and that of this amount 281,500,000 dols. went to Great Britain and her Colonies. Oil and tobacco account for 62,000,000 dols., or about 10 per cent. of the total exports, and countries under the British Crown took 14,000,000 dols. of these. On the whole, Great Britain and her dependencies must have absorbed at least one-half of the United States' domestic exports for the last financial year.

MR. CARLYLE ON MODERN WORK.

THE following letter from Mr. Carlyle to Sir J. Whitworth regarding the announcement made some months ago of the latter's intention to supplement the savings of his workpeople by a bonus upon them, was lately read by the Hon. and Rev. W. H. Lyttelton at a meeting of the Stourbridge School of Art:—"I have heard of your offer on behalf of the thrifty workpeople of Darley, and of the thankful acceptance of it by the district authorities of the place. I cannot resist the highly unwonted desire that has risen in me to say that I highly approve and applaud the ideas you have on the subject, and to declare in words that in my opinion nothing wiser, more beneficent, or worthy of your distinguished place as a master of workers has come before me for many a year. Would to Heaven that all or many of the captains of industry in England had a soul in them such as yours, and could do as you have done, or could still further co-operate with you in works and plans to the like effect. The look of England is to me at this moment abundantly ominous. The question of capital and labour growing ever more anarchic, insoluble altogether by the notions hitherto applied to it, is pretty certain to issue in petroleum one day, unless some other gospel than that of the 'dismal science' come to illuminate it. Two things are pretty sure to me; the first is that capital and labour never can or will agree together till they both first of all decide on doing their work faithfully throughout, and like men of conscience and honour, whose highest aim is to behave like faithful citizens of this universe, and obey the eternal commandment of Almighty God who made them. The second thing is that a sadder object than either that of the coal strike or any considerable strike is the fact that, loosely speaking, all England has decided that the profitablest way is to do its work ill, slimly, swiftly, and mendaciously. What a contrast between now and, say, only 100 years ago! At that latter date, or still more conspicuously for ages before that, all England awoke to its work with an invocation to the Eternal Maker to bless them in their day's labour and help them to do it well. Now, all England, shopkeepers, workmen, all manner of competing labourers, awaken as if with an unspoken but heartfelt prayer to Beelzebub, 'O, help us, thou great lord of shoddy, adulteration, and malfeasance, to do our work with a maximum of slimness, swiftness, profit, and mendacity; for the devil's sake. Amen.'"

NEW MAP OF THE UNITED STATES.

COMMISSIONER DRUMMOND, of the General Land Office, has just published his new map of the United States and Territories, which is compiled from the very latest surveys, and in some of its features it has no equal. The usual small detail has been dropped, for the purpose of showing all the township surveys. Every detached survey, even of a single township, is thus located; the correct location and boundary of all Indian reservations is given for the first time; the leading reservations made under treaty provisions are referred to by the act and page of the statute which records them; all the military reservations are correctly located, and the offices of the Surveyors-General and Law Registers and Receivers are given; all land grant railroads, completed or in progress, and nearly every other leading line, are accurately traced, and canals and lighthouses are also indicated. There are numerous corrections made. Shoshone Lake, for instance, which was always supposed to be the source of one of the main tributaries of the Missouri River, is now known to be the source of the Snake River, a tributary of the Columbia. This map was designed by the Commissioner to afford the largest amount of practical information, free from unimportant detail, and an inspection of the work shows that he has accomplished his purpose.

COTTON SEED.

THE United States House of Representatives Committee on Agriculture has made an adverse report on the joint resolution relative to the exchange of the seed of the cotton plant between the Khédive of Egypt and the Government of the United States, for the reason assigned by the Commissioner of Agriculture that the Egyptian seed, after trial, does not suit the southern climate. He says there is no country so far known that is equal to that of the United States in the production of cotton, and no seed so good as that grown there. Some years ago a large quantity of Egyptian seed was obtained by the department and sent to all the Southern States. There were no favourable reports of its success, it having failed in productiveness and especially in quality.

Chemistry applied to the Arts, Metallurgy, Chemical Manufactures, and Allied Subjects.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF CHEMICAL SOCIETIES, &c.

§ 1. *Acids, Alkalies, and Salts.*

PREPARATION of Tribromacetic Acid.—H. GAL prepares this substance by a process precisely analogous to that whereby trichloracetic acid is prepared from chloral hydrate, viz., oxidation by nitric acid, bromal hydrate being employed in the first instance. On cooling the product of the reaction, crystals form which produce violent inflammation when brought in contact with the skin in a moist state, but cause no ill result if handled when perfectly dry. *Comptes Rendus, lxxvii.* 786.

Iodoarsenic Acid.—ZINNO describes under this name a new compound which forms brilliant colourless crystals, and is produced by adding to solution of arsenious acid sufficient iodine to render the whole coloured; this body has a composition indicated by the formula $As_2 O_3 I_4$. *Bulletin de la Soc. Chim. Paris, xxi.* 175; from *Neues Repert. Pharm. xxii.* 385.

Ammonia in the Air.—TRUCHOT finds that the ammonia in the air increases with the elevation, whereas the contrary is the case with carbonic acid; thus he finds the following numbers:—

Locality.	Elevation.	Ammonia per cubic metre of air.
Clermont Ferrand	395 metres.	1·12 milligrammes.
Top of Puy de Dôme	1,146 „	3·18 „
Peak of Sancy .	. 1,888 „	5·55 „

Comptes Rendus, lxxvii. 1159.

Treatment of Ammoniacal Liquors.—CHEVALET patents the following details:—

1. Use of fatty matters to prevent frothing during distillation.
2. Separation of solid matters by settling after distillation.
3. Separation of solid matters from the liquors by operation in hermetically sealed vessels before distillation.
4. Special apparatus for the production of the alkali.

Bulletin de la Soc. Chim. Paris, xxi. 192.

Potassium Salts from India.—G. TSCHERMAK describes a new Indian mineral apparently analogous to the Stassfurth salts; it occurs in the "Salt range" in the northern Punjab, and is a mixture of *sylvin* (or potassium sulphate), *kieserite* (magnesian sulphate), and rock salt. The kieserite contains less water of crystallization than Epsom salts, being indicated by the formula $Mg SO_4, H_2 O$, whilst Epsom salts are represented by $Mg SO_4, 7 H_2O$. The "Salt range" belongs to the Silurian formation, wherefore this salt deposit is, perhaps, the most ancient of any yet known. *Jahrbuch für Mineralogie*, 1873, 642.

Soap-making.—VAN BAERLE patents the following process: the fat or oil is saponified in the usual way; when the operation is half completed, the whole is boiled up with 10 to 15 per cent. of a concentrated slightly alkaline solution of silicate of soda added in small quantities at a time; after cooling, from 3 to 5 per cent. of glycerine is added for the purpose of keeping the soap moist. *Bulletin de la Soc. Chim. Paris, xxi.* 189.

Salts of Glucinum.—ATTERBERG gives the results of his investigations on the salts of this metal, describing several basic sulphates, selenites, and succinates, and the neutral salts; the oxide, hydrate, and hydrated chloride; basic chlorides; the chlorostannate, chloroaurate, ferrocyanide, silicofluoride, cyanide, nitrate, perchlorate, periodate, molybdate, phosphate, formate, oxalate, and tartrate. Many of these compounds crystallize well. *Bulletin de la Soc. Chim. Paris, xxi.* 157.

Manufacture of Superphosphate of Lime.—VILLE patents the following additions to the processes previously described by him: the pasty mass formed by treating with sulphuric acid at 50° or 53° B. tribasic phosphate of lime free from alumina, is heated to 100°; if a temperature of 150° to 200° be employed, 1 equivalent of acid being used, a dicalcic phosphate is produced insoluble in water, but equally readily assimilated by plants. To this the inventor applies the name "disaggregated phosphate" (*phosphate désagrégé*).

Sulphuric acid may be replaced by hydrochloric acid with advantage in this process, the resulting chloride of calcium being readily washed out by cold water.

Special furnaces and drying ovens are also described. *Bulletin de la Soc. Chim. Paris, xxi.* 240.

Degradation of Phosphates.—ERLENMEYER has examined the question of the "degradation" of superphosphates (their conversion into insoluble substances on keeping); he finds that the monocalcic phosphate crystallizes in well formed tabular crystals indicated by the formula $H_4Ca (PO_4)_2 + 2 H_2O$; these lose their water of crystallization at 100°, but the desiccated substance takes up this water again by exposure to air; the hydrated crystals are not, however, hygroscopic if free from phosphoric acid. On treatment with cold water this crystallized monocalcic phosphate is decomposed, free phosphoric acid being formed and an insoluble dicalcic phosphate being produced; this latter is indicated by the formula $H Ca P O_4 + 2 H_2O$. On boiling the liquor, the water of crystallization of the dicalcic phosphate is eliminated, forming the anhydrous compound $HCa PO_4$. [BIRNBAUM found, on the contrary, that the monocalcic phosphate is wholly dissolved by water, the solution not being decomposed by boiling.]

When tribasic phosphate of lime is thoroughly intermixed with monocalcic phosphate, the two slowly act on one another, forming two equivalents of dicalcic phosphate; in a month the

action is complete on merely standing; but by boiling the mixture with alcohol, the transformation is completely effected in an hour; boiling alcohol transforms the monocalcic phosphate itself into free phosphoric acid and dicalcic phosphate.

Hence the degradation of superphosphate is due to the production of dicalcic phosphate. *Bulletin de la Soc. Chim. Paris, xxi.* 177; from *Neues Repert. Pharm. xxii.* 476.

§ 2. *Metallurgy.*

Iron and Steel.—WOODS and CLARK patent the preparation of peculiar steels by the addition to ordinary iron of from 1 to 5 per cent. of an alloy containing—

Tungsten	10 per cent.
Chromium	90 „

These steels possess great hardness, and are but little subject to rusting.

A silver white alloy suitable for specula is obtained by melting together two parts of steel and one part of the following alloy—

Tungsten	5 per cent.
Chromium	95 „

Bulletin de la Soc. Chim. Paris, xxi. 190.

Manufacture of Steel.—BIRCH proposes to remove phosphorus and sulphur from Bessemer steel by the introduction of oxidizing agents, &c. (metallic oxides, alkaline or earthy chlorides, &c.), *after* the blowing is finished. *Bulletin de la Soc. Chim. Paris, xxi.* 188.

Tempering Steel.—KULICKE gives the following process, which serves to restore altered or burnt steel: the article is heated to a cherry red, and then placed into a mixture containing,—

Tartaric acid	12 parts.
Fish-oil	60 „
Powdered charcoal	4 „
Boneblack	16 „
Yellow prussiate	20 „
Tallow	20 „
Burnt stag's horn	6 „

Chemical News, xxix. 93.

GARMAN & SIEGFRIED heat the steel to a cherry red, and sprinkle marine salt over it; it is then forged while hot into the required shape, the common salt being sprinkled over it from time to time during the process. Instead of common salt, the following mixture may be used:—

Common salt	2 parts.
Sulphate of copper	2 „
Sal ammoniac	2 „
Carbonate of Soda	2 „
Nitre	1 part.

In order to harden the steel after forging, it is heated to a cherry red, and then plunged into the following baths:—

Rain water	1 gallon.
Alum	1½ ounces.
Carbonate of soda	1½ „
Sulphate of copper	1½ „
Nitre	1 „
Common salt	6 „

Bulletin de la Soc. Chim. Paris, xxi. 232; from *Berg und Hüttenmännische-Zeitung*, 1873, No. 50.

Manganese Alloys.—SCHROTTER prepares alloys of copper and manganese by heating together in a plumbago crucible copper oxide, charcoal powder, and manganese oxide. These products contain about 99 per cent. of alloy, the remainder being carbon, sulphur, iron, silicon, &c. &c. The alloys containing

	No. 1.	No. 2.
Manganese	19	9
Copper	80	90
Other substances	1	1
	100	100

resemble packfong, and are applicable for the same purposes.

Another alloy, containing

Copper	64
Manganese	16
Zinc	20
	100

takes a high polish, and alters but little by exposure to air.

JAWORSKY has also obtained manganese-copper alloys by heating together copper scales with charcoal powder and manganese oxide. These contain from 10 to 30 per cent. of manganese; an alloy termed by the author *Zbenk* [from the initial letters of the German names of the ingredients used in its product, viz., Zink, Braunstein (manganese dioxide), Eisen (iron), Nickel and Kupfer (copper)]. It is brittle, but otherwise resembles packfong.

The alloy referred to as No. 1 (80 parts copper and 19 manganese) is scarcely affected by dilute boiling sulphuric acid, by hydrochloric acid, or by mercury; even when zinc is also present it is unacted upon by these re-agents. *Bulletin de la Soc. Chim. Paris, xxi.* 232. From *Dingler's Polytech. Journal, ccx.* 355.

Purification of Bismuth.—C. MEHU finds that bismuth containing sulphur and arsenic may be purified to a great extent by fusion and exposure to air at a sufficiently high temperature, the oxide formed being removed by stirring to the sides of the vessel as fast as produced; in this way the arsenic and sulphur are oxidized and volatilized. A more perfect purification is effected by fusion with potassium or sodium tartrate, whereby the alkali metal is partially reduced, forming an alloy with the bismuth. By fusion of this alloy and exposure to air, the alkali metal may be again removed. Continual stirring is requisite, or organic matters, *e.g.* wood, paper, &c., may be thrown into the fused mass, so as to convert the caustic potash formed into carbonate, this latter being less fusible, and therefore not forming a coating over the fluid mass, and so hindering the oxidation. When the alkali metal is completely oxidized, the bismuth should be poured off, otherwise it begins itself to oxidize. A mixture of alkaline carbonate and charcoal also answers satisfactorily instead of the alkaline tartrate; in any case the complete removal of the last traces of arsenic is very difficult. *Pharm. S. Trans.* [3] *iv.* 341.

New Uranium Ore.—A. SCHRAUF describes a new mineral from Joachimsthal consisting of a double carbonate of calcium and uranium, with traces of sulphuric acid; to this he gives the name *Schröckingerite. Jahrbuch für Mineralogie*, 1873. 646.

Utilization of Platinum Residues.—KNOESEL heats on the water-bath for some hours the residues, together with caustic potash or soda, and the alcoholic washings obtained in the mother liquors of chloroplatinate of potassium; the platinum is completely reduced as a spongy mass, and may be collected, washed, and converted into chloride, &c. *Berichte der Deut. Chem. Ges. vi.* 1159.

Cast-Steel.—H. A. LEVALLOIS prepares a cast-steel that is not easily liable to rust, and the cost of which is about the same as that of an ordinary cast-steel of good quality, varying according to the proportion of the elements employed. The improved process admits of perfect regularity in the manufacture of this particular quality of steel, composed of an alloy of iron, tungsten, and nickel, in the following proportions by weight:—

For the first quality:—

Soft iron	93 parts
Tungsten	6½ „
Nickel	1¼ „

For the second quality:—

Soft iron	95 parts
Tungsten	4½ „
Nickel	1½ „

For the third quality—

Soft iron	97 parts
Tungsten	2½ „
Nickel	1½ „

The furnaces and crucible used for this process are the same as those ordinarily employed in the manufacture of steel.

The tungsten and nickel are mixed together and enclosed with a flux in a soft sheet iron tube, the flux described hereafter being used in preference to others, in the proportion of one part of the said flux to one hundred of metal. The said tube is placed in the centre of the charge, which is sprinkled over with a quantity of the same flux, varying in inverse proportion to the quantity of metal treated, between one-half of one part and two entire parts of flux to one hundred parts of metal.

As soon as the mass has attained a liquid state it is run off in the usual way into a sand or metal mould, the latter being coated with a mixture of clay, carbon, and iron. Before and during the process of running off the fused metal a vacuum is produced either in the sand or metal mould by covering the bottom of the funnel with a parchment membrane, which is de-

stroyed by the contact of the fused metal. This membrane is fixed between the funnel and the tedge.

When the alloy is run into a metal mould the ingot is removed as soon as it becomes solidified, annealed in a closed vessel, and allowed to cool gradually.

The steel produced by the above process may be hammered in the same way as ordinary steel.

The flux previously referred to is composed of the following ingredients :—For a total of one hundred parts, thirty-six of common boric acid or sub-borate of soda, thirty-two parts of calcined flint, and thirty-two parts of washed carbonate of lime. These materials are pulverized in a mortar together and introduced in small quantities into a crucible at a white heat, liquefied, and run off on to a fluted cast-iron plate, and, lastly, the flux thus obtained is crushed into small pieces before it is used.

Presence of Thallium.—T. L. PHIPSON finds that thallium is much more widely distributed in nature than is usually supposed. It is met with in many minerals, but especially in metallic cadmium and the cupriferous pyrites of Spain and Norway. It can be separated in the state of sulphide by dissolving the raw material in a mixture of nitric and hydrochloric acid, treating the diluted acid solution with sulphuretted hydrogen gas, filtering, boiling the clear filtrate with a slight excess of sodium carbonate and filtering whilst still hot. This second filtrate yields on addition of ammonium sulphide the thallium in the form of sulphide.

§ 3. *Dyeing, Calico Printing, Tanning, Bleaching, and allied subjects.*

Indigo Extraction.—C. W. SMITH boils the plant with an alkaline carbonate solution of from 0·5° to 1° B. strength, whereby chlorophyll is removed. The liquor, which contains no indigo, is drawn off, and the residue treated with milk of lime at 2° to 5° B. ; 1 part of lime should be used per 10 parts of dry plant. When the mixture is boiling, from 1 to 3 per cent. of chloride or oxide of tin (*Stannous* compound) is added, or a mixture of the two. Ebullition is continued until the plant is thoroughly exhausted of indigo, which is known by taking out a sample from time to time. The whole is then allowed to stand so as to settle, and the clear liquor is run off into vats, where the indigo is precipitated.

This process is particularly well adapted to the treatment of the incompletely exhausted residue obtained in the ordinary method of indigo making. It is much less costly and more expeditious than this method, and gives a product of the purest quality. *Bulletin de la Soc. Chim. Paris, xxi.* 189.

Phenol Blue.—A new dye has been introduced into the market under this name. Its nature is not stated further than its production from phenol as starting point. It much resembles azuline. It has a violet shade, but becomes sensibly blue when the bath is acidified during dyeing. It occurs in crystalline flakes. When required for use it is dissolved in boiling water, the liquor being well stirred without boiling. The liquor should have the following composition —

Dyestuff	25 grammes.
Water	1 litre.

After subsidence for several hours, the clear liquor is syphoned off and used as with aniline dyes. *Moniteur de la Teinture*, 1874, *viii.* 6.

Campo-Bello Yellow.—SCHRODER & BEREND prepare from phenol a yellow dye sold under this name. It is in many respects analogous to naphthalene yellow, and can be used with wool or silk ; for the former the aqueous solution is filtered, the wool added, and the whole boiled for half an hour ; 300 grammes of alum may be added to the bath for every 5 kilogs. of wool, whereby a saving in dyestuff is occasioned. Silk is dyed as wool, but without boiling. *Moniteur de la Teinture, vii.* 283.

Bleaching Flannel.—Flannel which has become yellow with use may be bleached by putting it for some days in a solution of hard soap to which strong ammonia has been added. The best proportions are one pound and a-half of hard curd soap, fifty pounds of soft water, and two-thirds of a pound of strong ammonia solution. The same object may be attained in a shorter time by placing the flannel for a quarter of an hour in a weak solution of bisulphite of sodium, to which a little hydrochloric acid has been added.

Decolorization of Albumen, Gelatine, &c.—LIEBODART applies ozone for this purpose. The liquids to be decolorized are placed in a Babo's apparatus and a current of ozonized air made to bubble through them : serum is thus completely blanched. *Bulletin de la Soc. Chim. Paris, xxi.* 239.

Preparation of Dextrin.—BONDONNEAU finds that commercial dextrin invariably contains grape-sugar ; direct experiments showed that samples exposed to the following temperatures and for the annexed times gave the same result :—

Temperature.	Time.
50— 60	4 hours.
80—110	6 „
140—145	4 „
145—200	0·2 „
200	1·4 „

After the first 14 hours the fecula used becomes anhydrous, and the isomeric transformation then commences ; the production of dextrin is much facilitated by the presence of a little acid, but this also causes the formation of glucose ; the amount of this latter product formed depends on the amount of acid present ; it can also be formed in presence of a moist inert gas at a high temperature. *Bulletin de la Soc. Chim. Paris, xxi.* 149.

New Dyeing and Tanning Materials.—MICHEA patents the use of the following materials :—

1. The leaves of the *canocarpus latifolia*, or a decoction made therefrom, for dyeing and tanning purposes.
2. The leaves of *myrobolana emblica*, or a decoction thereof, for dyeing, printing, or tanning.
3. "Canocarpine" for dyeing.

This last substance is the colouring principle of the *canocarpus latifolia ;* it is obtained as a precipitate, soluble on heating, on evaporation of the decoction of the leaves to a syrupy consistence ; it gives a black with iron salts.

The *myrobolana* extract gives solid brown shades in calico printing, the tints varying with the mordant used ; with iron salts it strikes a blue-black shade forming a precipitate.

The barks of *butea frondosa* and *butea Gibs.*, or decoctions of these barks, may also be employed for the same purposes ; the cellulose of these barks answers for the manufacture of paper pulp. *Bulletin de la Soc. Chim. Paris, xxi.* 239.

Rapid Method of Tanning.—RAMSPACHER patents a special apparatus whereby tanning liquors or other substances can be forced into hides. *French Patent, No.* 96,582. *Bulletin de la Soc. Chim. Paris, xxi.* 237.

Valuation of Tannin.—PRUDHOMME adds an aniline colour, and then a solution of bleaching powder of known strength ; the colour added is not acted upon till all the tannin is destroyed, so that by reading off the amount of bleaching-powder liquor employed to bleach the coloured liquid, and subtracting therefrom that equivalent to the aniline-colour acid, the amount of tannin present can be found. Methyl green seems to give the best results, though fuchsine, soluble blue or Paris violet may be used.

The tannin may be precipitated by methyl green, and the lake thus formed filtered off, washed, and treated with bleaching powder solution. *Bulletin de la Soc. Chim. Paris, xxi.* 169.

Manufacture of Whitelead.—E. MILNER agitates minium with common salt solution ; a flocculent precipitate is formed consisting of an oxychloride of lead ; this is converted into carbonate by passing a current of carbonic acid through the liquid to saturation ; the following proportions give the best result :—

Water	30 to 40 parts.
Salt	1 „
Minium	10 „

Bulletin de la Soc. Chim. Paris, xxi. 190.

§ 4. *Food and Sanitary Matters.*

Australian Mutton Soup.—A. VOELCKER has examined the concentrated liquor sold under this name, with the following results :—

First Quality. From a single sheep about 1 lb. of first-rate extract is obtained, by simply straining off the liquor from which the fat has separated and concentrating.

Water	29·20
Nitrogenous organic matter	60·48
Ash	10·32
	100·00
Nitrogen	8·68
Amount soluble in 80 per cent. alcohol . .	33·51

Second quality. About 2½ lbs. of this is obtainable after the first quality has been separated.

Water	31·29	29·70
Nitrogenous organic matter	64·62	66·29
Ash	4·09	4·01
	100·00	100·00
Nitrogen	10·75	10·96
Amount soluble in 80 per cent. alcohol	20·27	17·89

Pigs were fed with this soup with the result that ½ lb. of soup did not appear to be capable of replacing 1 lb. of peas, the pigs losing weight after seven days trial. In another experiment where all the pigs had a liberal diet—some having the soup as well—the latter set gained nearly twice as much in weight as the others, and realized a larger profit, notwithstanding the higher cost of the soup. The soup thus appears to act as a condiment rather than as a true food. *Journal of the Royal Agricultural Society*, 1873, 428.

Artificial Milk.—LIEBIG has prepared the following mixture as a substitute for human milk, which it resembles pretty closely in composition :—

Wheaten flour	16 parts.
Skimmed milk	160 „
Bruised malt	16 „
Water	32 „
Solution of bicarbonate of potassium	3 „

The latter ingredient is prepared by mixing together

Potassium bicarbonate	2 parts.
Water	11 „

and allowing to stand until dissolved.

The flour is boiled with the milk until a homogeneous paste is formed ; the malt is stirred with the water, and the two liquids mixed ; the bicarbonate solution is then added, and the vessel containing the whole immersed in hot water, so as to warm the mixture ; after fifteen to twenty minutes the liquid is strained through a fine hair sieve, and allowed to stand a short time before use. This artificial milk will keep for twenty-four hours.

Sugar Manufacture.—POSSOZ patents the use of volatile substances such as benzene, light naphtha, and petroleum oils, &c., &c., for the prevention of decomposition of sugar juices, to be used instead of carbolic acid. *Bulletin de la Soc. Chim. Paris, xxi.* 191.

New Varieties of Sugars.—A. GIRARD has examined some saccharine bodies derived from Gaboon caoutchouc and other varieties of this substance from Borneo and Madagascar. To these he gives the names Dambonite, Bornesite, Matezo dambose, Matezite, Dambose, and Borneo dambose ; the names being partially derived from the native names for caoutchouc (n'dambo, and matezo). These new sugars melt at temperatures varying from 181° to 235°, and all are either inert as regards polarized light, or rotate the plane of polarization to the right. *Comptes Rendus, lxxvii.* 995.

Purification of Syrups.—MARGUERITTE patents the following particulars :—

(1) Use of acids generally (including carbonic acid) for the displacement of the volatile acid contained in the beet juice, whereby the development of peculiar odours, &c., from the nitrogenous destructive substances present is for the most part avoided.
(2) Addition of acids to the juice for scumming, &c., &c.
(3) Evaporation in vacuo at as low a temperature as possible.

Hydrochloric acid is more particularly recommended ; by this means the following advantages are gained.
(1) Improved taste and odour of the syrups, &c., made.
(2) Increased yield of crystallized sugar.
(3) Diminution of the amount of alkalies retained by the mother liquors, and of the consequently large loss of sugar thereby rendered imperative.
(4) Production of thinner syrups and molasses, &c., whereby the "turbinage" is more readily effected.

The syrup should be at 30° B. ; for 100 kilos. of syrup 3·094 kilos. of acid at 20° B., equal to 2·668 litres, are required in the case of after-crops of crystals containing 16 per cent. of ash. *Bulletin de la Soc. Chim. Paris, xxi.* 238.

Beetroot in Brewing.—Beets have hitherto been rarely used for brewing, as they are apt to communicate an unpleasant flavour to the beer brewed from them ; processes have been recently invented whereby this difficulty is stated to be overcome, but the details are for the most part kept secret ; the washed beets are crushed and exhausted with boiling water, and the extract mixed with malt ; hops are added and the further treatment is the same as in ordinary brewing. *Dingler's Polytech. Journal, ccx.* 478.

Valuation of Starch.—BONDONNEAU states that when starch contains only 2 to 3 per cent. of impurities, the feculometer of Block gives indications which are not always trustworthy from the following causes ; the nature of the impurity present influences the result differently in each particular case ; the following are the chief causes of alteration, or the chief adulterations.

(1.) Fermentation.
(2.) Desiccation at too high a pressure.
(3.) Presence of sand or cellulose owing to imperfect manufacture.
(4.) Addition of pulverized potato pulp.

In the first two cases the error rarely amounts to 1 per cent., but in the latter two instances errors of 3 per cent. may be introduced readily.

Four to five grammes of starch are disseminated through 100 cc. of water ; 3 to 4 cc. of strong caustic soda solution are then added ; pure starch thus gives a colourless translucent liquid, whilst starch containing cellulose, &c., forms a more or less yellowish product ; on adding hydrochloric acid, the starch is dissolved, whilst cellulose, sand, &c., sink to the bottom, and may be examined by the microscope. *Bulletin de la Soc. Chim. Paris, xxi.* 147.

Preservation of Eggs.—F. C. CALVERT states that eggs may be kept without change in an atmosphere of nitrogen, hydrogen, or carbonic acid for as long as three months, whether they are entire or pierced at the end by a fine needle. In dry oxygen eggs undergo no change, but in moist oxygen the egg becomes covered with a white filamentous mould. *Comptes Rendus, lxxvii.* 1024.

Gypsum in Agriculture.—P. DESCHAMPS finds the following results by the use of sulphate of lime and common salt as manure for winter tares ; the use of salt enables the water to take up much more gypsum than it otherwise would do.

Per hectare.	Kilogs. grain.	Kilogs. straw.
4 hectolitres gypsum	962	2400
4 hectolitres gypsum and 60 kilogrammes common salt	1324	4100
2 hectolitres gypsum and 200 kilogrammes nitrate of potassium	1600	3300

Les Mondes, Jan. 29, 1874.

Preserved Food.—J. R. WEED mixes meat, fish, &c. with various vegetables, and frees the mixture from all its moisture. The articles thus prepared are said to keep for a very long time. He gives the following receipts :—

Vegetable Soup.—Meat, 256 parts ; potatoes, 128 parts ; onions, 64 parts ; tomatoes, 64 parts ; carrots, 32 parts ; turnips, 16 parts ; peas, 32 parts ; cabbage, 16 parts ; barley, 64 parts ; rice, 64 parts ; okra, 5 parts ; celery, 4 parts ; parsley, 4 parts ; thyme or other sweet herbs, 4 parts ; pepper 2 parts, with or without other condiments.

Pea Soup.—Meat, 12 parts ; peas or beans, 16 parts ; onions, 1 part ; thyme or other condiments, 1 part ; potatoes, 16 parts.

Lentil and Rice Soup.—Rice, 8 parts ; lentils, 8 parts ; meat, 12 parts ; potatoes, 8 parts ; condiments to suit.

Turtle Soup.—Turtle, 8 parts ; potatoes, 4 parts ; sweet herbs, onions, eggs, sago, sugar, cloves, mace, and condiments to suit.

Fish and Vegetables.—Fish, 5 parts ; potatoes, 5 parts ; eggs to suit ; condiments to suit.

Fish Chowder.—Fish or shell fish, 14 parts ; potatoes, 10 parts ; onions, 5 parts ; tomatoes, 5 parts ; bread or biscuits, 8 parts ; salt pork, 2 parts ; condiments to suit.

Chicken Soup.—Chicken, 16 parts ; barley, 4 parts ; rice, 4 parts ; parsley, 1 part ; thyme, ½ part ; condiments to suit.

Hash.—Meat, 16 parts ; potatoes, 16 parts ; onions, 8 parts ; parsley, 1 part ; turnips, 4 parts ; condiments to suit.

Heart-Disease and Overwork.—HOUGHTON states that the early break-down of health observed among Cornish miners, and commonly regarded as an affection of the lungs—"miners' phthisis"—proceeds rather from disturbed action of the heart ; this is caused by the great and sudden strain put upon the system by the ascent from the pits, at a time when the body is not sufficiently fortified with food. The labour of the miner is peculiar, and his food is badly suited to meet its requirements. At the close of a hard day's toil the weary miner has to climb, by

vertical ladders, through a height of from 600 to 1,200 feet, before he can reach his cottage, where he naturally looks for his food and sleep. This climbing of the ladders is performed hastily, almost as a gymnastic feat, and throws a heavy strain (amounting to from one-eighth to one-quarter of the whole day's work) upon the muscles of the tired miner, during the half-hour or hour that concludes his daily toil. A flesh-fed man (as a Red Indian) would run up the ladders like a cat, using the stores of force already in reserve in his blood; but the Cornish miner, who is fed chiefly upon dough and fat, finds himself greatly distressed by the climbing of the ladders—more so, indeed, than by the slower labour of quarrying in the mine. His heart, overstimulated by the rapid exertion of muscular work, beats more and more quickly in its efforts to oxidate the blood in the lungs, and so supply the force required. Local congestion of the lung itself frequently follows, and lays the foundation for the affection so graphically though sadly described by the miner at forty years of age, who tells you that his other works are very good, but that he is "beginning to leak in the valves."

§ 5. *Fuel, Gas, Illumination, Photography, &c.*

New Substitute for Coal.—A short time ago, a Belgian peasant made the extraordinary discovery that earth, coal, and soda mixed together would burn as well as and better than any other combustible, and the fact has since then been proved beyond a doubt. The way in which he found this out is curious; he had been scraping the floor of his cellar with a shovel in order to bring all the bits of coal lying about in a heap, which, mixed as it was with earth and other impurities, he put into his stove. To his astonishment, he found that this accidental compound burnt better instead of worse than he expected, and emitted greater heat. Being an intelligent man, he endeavoured to discover the cause, and discovered that a good deal of soda, probably the remnant of the last wash, lay about the floor of the cellar, and that some of it must have got into his heap. He then made a few experiments, and at length improved his compound sufficiently to render it practical. The publicity given in Belgium to this discovery has caused trials to be made everywhere, and it has now been ascertained that three parts of earth and one of coal dust, watered with a concentrated solution of soda, will burn well and emit great heat. Many Parisian papers talked of it, but only one went so far as to make the experiment at its printing office. A certain quantity of friable and slightly sandy earth was mixed with the quantum of coal dust prescribed; the two ingredients were well incorporated with each other, and then made into a paste with the solution above mentioned. The fireplace of one of the boilers had previously been lighted with coal, and the fire was kept up with shovelfuls of the mixture. The latter in a few seconds was transformed into a dry brown crust, which soon became red hot, and then burnt brightly, but without being rapidly consumed. The fact of the combustion is, therefore, well ascertained; but before the system can be universally adopted, there are some important points to be considered—such as the calorific power of the mixture compared with that of pure coal, its price, and above all, a remedy for the great drawback attaching to it—its fouling the firegrate considerably. —*Galignani.*

Peat as Fuel.—The engineers of the Belfast and Northern Counties Railway report that the average peat fuel used per mile run in experimental trials, was 21·47 lbs.; whilst the average obtained by the use of coal (mixture of 2 parts Welsh to 1 of Scotch) was 25·25 lbs. in three months. In another month the average was 26·29 lbs. of coal. *Chemical News, xxix.* 98.

HEDDLE states that peat-fuel, prepared by the South of Scotland Peat Fuel Company, gives the following results on analysis:—

Gas	50·2
Carbon	25·9
Ash	7·2
Water	16·7
	100·0

Calculated on the dry substance, this represents:—

Gas	60·3
Carbon	31·1
Ash	8·6
	100·0

Ibid. 99.

Gas from Peat.—Experiments have been made at the Commercial Gasworks, London, giving the following results:—

Nature of peat.	Cubic feet of gas.	Illuminating power.	Coke in cwts.	Gas per ton, equal to lbs. of sperm.
Belfast	10,500	15·65	8	562
Creavelea	9,240	18·75	8·75	594
Welsh	11,000	22·50	7	849

These results may be contrasted with the following, obtained with various kinds of coal:—

Nature of coal.	Cubic feet of gas.	Illuminating power.	Coke in cwts.	Gas per ton, equal to lbs. of sperm.
Staffordshire	7,100	12·42	13·5	302
Derbyshire	7,000	11·71	17	305
Lochgelly	8,000	18·00	13	494
Derbyshire Cannel	8,500	20·60	15	600
Wigan	10,000	20·00	13·25	686
Newcastle	9,800	25·00	13·25	840
Lesmahago	10,500	40·00	10	1,440
Boghead, No. 1	12,500	40·00	8	1,713
Boghead, No. 2	13,000	48·00	6	2,220

Chemical News, xxix. 98.

Production of Gas.—HENGST and MUCHAMP patent the blowing of steam into retorts filled with red-hot coke, so as to generate hydrogen (and carbonic oxide). *Bulletin de la Soc. Chim. Paris, xxi.* 187.

Manufacture of Hydrogen.—CHRISTOPHLE and LACKERSTEEN patent the production of hydrogen by the action of superheated steam on manganese or its alloys. *Bulletin de la Soc. Chim. Paris, xxi.* 190.

Match Composition.—COURVOISIER patents the following composition for tipping matches—

Phosphorus	20·0 per cent.
Gun-cotton	5·5 „
Dust of wood	5·0 „
Iron-filings or steel-dust	5·0 „
Sulphur	54·5 „
Gum.	10·0 „
	100·0

These different materials are mixed in the water-bath in such a fashion as to produce a soft paste, into which the ends of the matches are dipped. *Bulletin de la Soc. Chim. Paris, xxi.* 192.

Artificial Fuel.—Small coal, or peat, or a mixture of both, is mixed with a solution of silicate of soda or other soluble silicate, together with aluminous clay, or chalk, or lime; and, to prevent the formation of clinker, a small quantity (from about one-quarter per cent. to one per cent.) of any of the following five ingredients is added:—

1. Permanganate of potash or soda.
2. Nitrate of potash or soda.
3. Peroxide of manganese.
4. Oxide of iron; or,
5. Chlorate of soda or potash.

The lime, or chalk, or other ingredients are first added to the coal or peat, or coal and peat, in the proportion of about 4 per cent. to 90 per cent. of coal, or coal and peat, after which the solution of silicate, about 5 per cent., is added, and when well mixed is pressed into blocks.

§ 6. *Miscellaneous.*

Composition for Preserving Wood, Metals, Textile Fabrics, &c.—MOLLER patents the use of the following mixture:—

Crude tar as delivered from the gasworks	60 parts
Paste of chloride of lead precipitated and washed, and containing 25 per cent. of water	7 „
Elutriated pipe-clay dried and pulverized	15 „
Water	18 „

The latter materials are mixed with the water, and the whole well mixed; the tar is then added, and the whole well mixed together. Various argillaceous substances can be used in lieu of the pipe-clay. *Bulletin de la Soc. Chim. Paris, xxi.* 237.

Preservative Paints for Ships' Bottoms.—DUBOIS patents the use of compositions containing sulpho-cyanide of copper as a preservative agent for ships' bottoms, the adherence of mollusca and marine vegetation being thereby prevented. *Bulletin de la Soc. Chim. Paris, xxi.* 240.

Mastic Impervious to Moisture for Walls, &c.—CAZENAVE patents the use of the following composition :—

Tallow	30 kilos.
Resin	36 „
Ochre	9 „
Cement	60 „

Larger quantities of resin and cement may also be employed. The mastic must be softened by heat before use. *Bulletin de la Soc. Chim. Paris, xxi.* 237.

New Textile Fabric.—DUPONT patents the use of the *Typha latifolia* as a source of textile materials. The stems and leaves are macerated for six days in the following mixtures :—

Water	500 parts.
Quicklime	95 „
Sulphur	5 „

They are then well washed and scutched, and are then ready for bleaching, &c. *Bulletin de la Soc. Chim. Paris, xxi.* 188.

Valuation of Anthracene.—E. LUCK gives the following process :—1 gramme of the sample to be examined is dissolved in 45 ccs. of boiling glacial acetic acid ; to the solution (filtered if necessary) 10 grammes of chromic acid, dissolved in 5 ccs. of water and 5 of glacial acetic acid, are gradually added, the solution being kept quietly boiling ; when a permanent yellowish-green colour is developed, or when a drop of filtered liquid placed on a silver coin gives a reddish spot of silver chromate, the whole is allowed to cool, and then diluted with 150 ccs. of water. After standing for some hours the whole is filtered, and the separated quinone washed with water and potash solution, dried at 100°, and weighed. The acetic acid solution used dissolves 0·010 gramme of anthraquinone, which quantity must therefore be added to the weight found. *Chemical News, xxix.* 102. From *Berichte der Deut. Chem. Ges.*

Electro-magnetic Signalling Apparatus.—L. FINGER proposes to use a new instrument, composed of two separate portions, each arranged and operated so that a ball or other suitable body inserted through an aperture formed, descends a series of inclined planes or movable levers, and as it approaches the end of each lever or plane brings a metallic pin or stem connected with the bottom of the lever and with one wire of an electrical battery in contact with a metallic plate connected with the other portion of the annunciator and the opposite wire of the battery, and closes the electrical circuit, by which a series of mechanical devices are operated so as to strike a bell and partly revolve a cylinder or drum arranged on its periphery with blanks, names, and numbers to the proper distance required to bring to view the number of the room and the name of the article or person wanted. Within each apartment and immediately adjacent to the wire knob is placed a card giving the proper directions for effecting the call. A modification of this mode of signalling would be to employ a number of stops equal to the number of articles designated on the register, and a register card so placed or combined with the stop that each of the latter shall have a name. There is also combined with this annunciator a device for detecting the presence of fire in any room or apartment with which the register is connected. To any suitable portion of the case a bulb or vessel composed of glass or any suitable material is attached, and having two cells or chambers, the lower and larger one of which is to receive and contain a quantity of quicksilver, and the upper and smaller one being to receive any excess of such quicksilver which the expansion of the latter will force into it. The wire from the battery is introduced into the small cell and nearly in contact with the quicksilver in the chamber, or at such a distance that the latter when subjected to a degree of heat of about 100° Fah. shall expand and communicate with the said wire, and thereby close the circuit with the other wire, which conducts to the register.

New Weather Vane.—JANY proposes the following arrangement in place of the old weathercock, which has three essential faults—it indicates a direction when there is a dead calm, it gives no means of learning the force of the wind, and it fails to show the true course of the same, by exhibiting merely its horizontal component. The new weathercock is attached to the ordinary lightning rod ; just above a suitable shoulder on the latter is placed a copper ring, grooved and made into a pulley easily rotated in a horizontal plane. Around this passes a knotted cord, the ends of which are secured to the extremities of a short stick or metal rod, to which is secured a simple streamer. Thus constructed, the vane indicates a calm by falling vertically, and besides shows the strength of the wind by being blown out more or less from the lightning rod. As is evident, it is capable of motion in every direction, so that if there exist in the wind an upward-tending, vertical component, the same will be shown.

Scale of Baume's Hydrometer.—BERTHELOT COULIER & D'ALMEIDA have determined the specific gravity of the standard lime solution used in graduating this hydrometer ; this contains

Chloride of sodium	15 parts.
Pure water	85 „

the specific gravity of this solution at a temperature of 12° 5′ C. and a pressure of 760 millimetres is found to be 1·11057, the weighings being made in air with brass weights ; water has at this temperature the specific gravity 0·998404, the weighings being made in the same way. *Comptes Rendus, lxxvii.* 970. Compare "Practical Magazine," March, 1873.

COAL-CUTTING BY MACHINERY.—ITS PROBABLE INFLUENCE ON THE FUTURE OF COAL-MINING INDUSTRY.

By JAMES S. JEANS.[1]

SOME of the wisest philosophers have taught us that the more a man has learned the more he finds he has to learn ; and we are all familiar with the sage reflection of Sir Isaac Newton, who, with all his knowledge, declared that to himself he seemed to be like a man walking by the sea-shore, and gathering here and there a stray pebble, while the great ocean of truth lay all undiscovered before him. Some such thought as this occurs to my mind when I survey the very wide question of the potential results of the application of mechanical appliances to coal-mining. It is a subject upon which I have bestowed some little attention, otherwise I should never have presumed to appear before you this evening ; but it is also a subject which the more I study, the more I am impressed with its vast scope and importance. Nothing is further from my thoughts than to read you a historical essay on the triumphs and failures of coal-cutting machines. Many volumes would be required to do anything like justice to such a task. All that I now propose is to speak of certain well-attested results of the operation of coal cutting machinery, to lay before you some interesting facts and calculations with which I have been furnished in further attestation of these results, and to draw your attention to certain important conclusions which may be deduced therefrom. Before attempting this, however, let me briefly put you in possession of the following preliminary facts :—

The idea of substituting mechanical appliances for hand labour in the hewing of coal is not a new one. From a paper read some years ago before the North of England Institute of Mining and Mechanical Engineers, I have ascertained that so far back as 1761, one Michael Menzies, of Newcastle, took out a patent for this purpose. In 1762 another patent was taken out for cutting coal by machinery ; the next patent was taken out in 1783 ; and the next in 1818, so that between the latter two dates there was a long period of inaction, so far as this sphere of invention is concerned. Other patents followed in 1830, 1843, and 1846 respectively. From 1846 to 1852 no fresh patent was taken out, but between the latter year and 1864 no less than twelve new patents were obtained. In 1866, Gleadhill took out a patent for cutting coal by an endless chain and jib projecting from the side of the machine and forced through the coal by the forward motion of the carriage. This patent has since been modified and improved by Messrs. William Baird and Company, of Glasgow, and it is now known as the Gartsherrie machine, by which name I shall again have occasion to speak of it. Up to the period at which we have now arrived, very little encouragement was given to the patentees of coal-cutting machines. It is probable, indeed, that in no phase of human invention had ingenuity and money been spent to so little purpose. People had not then learned to face the probability of an ultimate exhaustion of our coal supply ; nor had they experienced the expense and inconvenience of a coal famine. The output of coal was sufficient and often more than sufficient for all our requirements. Coal that now costs 16*s.* to 20*s.* per ton was then a drug in the market at 3*s.* to 4*s.* per ton, so that there was no direct incentive to substitute mechanical for hand labour. But some eight or nine years ago the extraordinary increase in the production of coal (which advanced from sixty-five million tons in 1855 to ninety-eight million tons in 1865), and the

[1] Read before the Cleveland Institution of Engineers, January 15, 1874.

GEMS OF THE VIENNA EXHIBITION.—BREAKFAST SERVICE, AFTER THE CHINESE, SÈVRES PORCELAIN.

equally remarkable increment of consumption (which advanced from 2 tons 14 cwt. 5 lbs. per head of the population in 1855 to 3 tons 13 cwt. 2 qrs. 24 lbs. in 1865), caused more attention to be paid to the question of coal mining, not only by coal owners, but also by statisticians and political economists. In the session of 1865 the Council of the North of England Institute of Mining and Mechanical Engineers appointed thirteen of their number to report upon the performance of any coal-cutting machines which might be on trial; but the only report that these gentlemen ever made was that they had not been favoured with any communications on the subject, although they made enquiries in all the principal coal mining districts throughout the country. In a paper read before the mining and mechanical engineers of the North in the session 1864-65, Mr. T. W. Embleton stated that there were then three machines in operation—one upon the slotting principle at Kippax Colliery, near Leeds; Firth's machine, on the pick principle, at Hetton Colliery; and Harrison's rotary machine at the Bishop's Close Colliery. From 1761 to 1869 there were altogether 104 patents taken out for coal-cutting machines, and of this large number I think I am safe in saying that not more than half-a-dozen are now in successful use, while the vast majority have long since been relegated to the limbo of unlucky ventures.

In speaking of the results of coal-cutting machinery, we are bound to take into account the best results of the best machines yet invented. The adoption of this course will probably lead to what some would call invidious distinctions, but in no other way can we secure a fair datum line from which to draw our conclusions. The best results already obtained by coal cutting machinery, are likely, in course of time, and as that class of machinery becomes more perfect, to take the rank of average, or it may be of the worst results. In this direction there is such unlimited scope for progression that we cannot possibly stop where we are. So far as I have been able to ascertain, the machines most generally and profitably used at the present day are those of Mr. William Firth, of Leeds, and of Messrs Baird, of Gartsherrie. Respecting the former, the patentee read a paper before the British Association in August last. He stated that in "long wall" working, one of his machines would, under favourable conditions, cut twenty yards in an hour to the depth of 3 ft.; but 10 yards per hour, or 60 yards in a shift, was very good work, being equal to the day's work of twelve average men, whereas a man, a youth, and a boy were the only persons employed to work the machine. It is true that three are nominally sufficient to work the machine—that is, to remove and lay down the road and clear away the *débris;* but that number does not fairly represent the total amount of labour necessary to get the coal. In working with machinery, as in working by hand, it requires hewers, brushers, deputies, putters, and other colliery operatives to bring the coal to bank; and partial statements like that made by Mr. Firth are calculated to convey to the non-practical mind the impression that the services of all these hands are more or less dispensed with. Firth's machine has been at work at the Hetton Colliery for ten years, with longer or shorter intervals of repose. Its results have been variable, but on the whole satisfactory. The principle of the Firth machine is not, however, theoretically sound. Like the Levick and Jones machine (which was also tried at Hetton in 1867), it is found that one half the power necessary to work the machine is lost in drawing the pick back to strike another blow. In the rotary machine, such as those of Baird's and Winstanley's, all this loss of power is avoided, so that to this extent the one principle is much superior to the other. The simplicity of the Firth machine, and its consequent non-liability to get out of order, are, however, advantages of great importance, and have more than once led to its preferment over other machines that are more theoretically perfect according to the canons of engineering science. A table with which I have been supplied from a private source shows that, in experiments made at Hetton Colliery, there was a difference of 8·42 per cent. in favour of the Firth machine, as compared with hand labour, in the production of best coal.

With reference to the Gartsherrie machine, I speak the candid opinion of many practical men, and without any conscious partiality, when I say that it is the most perfect that has yet been devised. For the last six or seven years the Messrs. Baird have carried out successive improvements on this machine, at a large expenditure of labour and money. Until last year it was used only in the collieries belonging to the Gartsherrie firm, where it regularly cut from 300 to 350 feet per shift of eight hours, representing a yield of 75 tons of coal. The first of these machines introduced into England found its way to the Hetton Colliery, where it has now been at work for nearly twelve months. Of its operation at Hetton, I am in a position to give you some accurate data obtained over a long course of experiments, although not under the most favourable circumstances. Let me say here, for the sake of conciseness, that the principal advantages claimed for the Gartsherrie machine are—

(1.) A diminished cost of production;
(2.) An improved ventilation;
(3.) A reduction of waste; and
(4.) A relief of the miner from the hardest part of his toil.

(1.) It is highly important to ascertain the extent to which the Gartsherrie machine fulfils these conditions. It has not yet been tried on a scale sufficiently large and complete to give a definite idea of the minimum cost of production; nor are we likely to arrive at this result for some time to come. At the Hetton Colliery, however, the following approximate estimate, based on the result of a year's working, gives the cost and the number of men required to remove 120 yards of coal (equal to 130 tons) "kived" or holed by the Gartsherrie coal cutter:—

No. of men.		Cost. s.	d.
24	hewers, per ton	1	5
8	deputies „	0	5
6	putters „	0	2½
6	men at cutters	0	3¾
3	brake and foremen	0	1¾
2	men repairing cutter chain	0	1¼
49		2	7¼

To get the same quantity of coal at Hetton Colliery by hand hewing would require—

No. of men.		Cost. s.	d.
67	hewers, per ton	3	3
6	putters „	0	2½
6	deputies „	0	3¾
79		3	9¼

Showing a difference in favour of the coal cutter of 1*s.* 2*d.* per ton.

At the Espieside Colliery, belonging to the Messrs. Baird, the Gartsherrie coal cutter required, to produce 120 yards of coal (equal to 80 tons)—as per data supplied by Mr. William Stevenson, the underground manager—

No. of men.		Cost. s.	d.
15	hewers per ton	2	4
10	brushers „		
5	putters „		
3	men at cutter „	0	6¾
2	brake and firemen, per ton	0	1¾
2	men repairing cutter chain	0	1¼
37		3	1¾

The difference of 6½*d.* per ton between Hetton and Espieside is due to the fact that the seam worked at the former colliery is 4 ft. thick, whereas at the latter colliery it is only 2 ft. 6 in. In both cases, however, it is assumed that the coal is brought 130 yards from the face of the workings by the putters.

In these calculations no allowance is made for the motive power required to work the machinery. In the earlier days of mechanical coal-cutting, there was a considerable difference of opinion as to whether compressed air or water supplied the cheapest and most practicable power. Water is used by Carrit to actuate his machine, but by far the greater number of such machines have been worked with compressed air. Although it has been urged that in the use of compressed air a portion of the power is lost by displacement of the latent heat, whereas by the use of water the only loss is that arising from friction, it is now universally admitted that air is a more reliable and more advantageous motor for this purpose than any other. To generate the compressed air involves the cost of a considerable quantity of fuel, but that quantity will vary very little whether the number of machines at work be one or a dozen, and at the pit mouth its cost will not be seriously felt. I am not in a position to give even an approximate idea of the consumption of fuel necessary to work the Gartsherrie machine; but if we assume that it will represent a penny per ton on the gross output, and that other incidental charges, such as those necessary to keep the machine in order, will be covered by a penny per ton more, we have a residual economy of a shilling per ton by the substitution of mechanical for hand labour. By this calculation, then, we arrive at the fact that if coal-cutting machinery were universally adopted, there would be an economy of at least £6,000,000 effected in raising the 120,000,000 tons of coal now annually produced in the United Kingdom. I say at least

£6,000,000, because there is no doubt, if our collieries were worked entirely by mechanical power, the distance in favour of coal-cutting machinery would be very much greater than any results hitherto obtained have proved to be practicable.

Another important consideration germane to this phase of our subject, is the extent to which the application of coal-cutting by machinery would reduce the number of colliery operatives. The results obtained at the Hetton and Gartsherrie Collieries proved that, by using coal-cutting machinery, 49 men can do the same amount of work as 79 by hand hewing. But the more extensively coal-cutting by machinery is adopted the greater this reduction will become, and I shall certainly not be overstepping the mark, if I estimate, that we could dispense with at least one half of the men now employed in our coal mines, in the event of mechanical hewing becoming the rule instead of the exception; or, in other words, the 418,088 men employed in raising our output of 123,393,853 tons of coal last year might be reduced to almost 200,000. The transition from hand labour to mechanical, will probably be so slowly accomplished, that we shall never be able to realize the full value of this reduction. We need not, in an alarmist spirit, contemplate the possibility of 200,000 men being all at once and without any warning deprived of employment. The commissioners appointed to inquire into the probable extent and duration of our coal supplies, have calculated, on the basis of diminishing ratios, that within a hundred years from now our home consumption of coal will reach the gigantic total of 274,000,000 tons per annum, or considerably more than double our total output of coal at the present time, and if our export trade is increased in the same ratio, the production of coal in the United Kingdom will be nearly four times greater in 1974 than it is likely to be during the current year. The large and rapid development of our coal resources will, however, so keep pace with the substitution of mechanical for manual labour in our mines, that there is no reason why trades-unionists or any other class should fear the effects of the change. On the contrary, there is already such a dearth of skilled miners throughout the country, that we shall have the utmost difficulty in keeping the supply of coals abreast of the demand, unless this change is permitted to take effect. The government inspector's returns show that the number of miners employed in the United Kingdom advanced from 370,881 in 1871 to 418,088 in 1872, being an increase within a single year of 47,207. This increase is not a natural one: it is not dependent upon those who are "native and to the manner born," but is due to a large external accretion of operatives, recruiting the ranks of our miners from other kinds and branches of labour. The introduction of coal-cutting machinery seems to be the only means of so regulating the demand for colliery labour as to enable the supply to respond to it in an even and natural way.

(2.) The next great merit claimed for coal-cutting machinery is an improvement in the ventilation of our mines. Everybody knows that good ventilation is one of the greatest desiderata in coal mining; that the miner's health and safety are dependent upon it; and that, while it is one of the most essential, it is also one of the most difficult duties of the mining engineer. The question of ventilation is, moreover, closely bound up with the extent and duration of our available coal supply. It has often been to me a matter, both of surprise and of regret, that the Commissioners, appointed by Parliament to inquire into [1]this subject, took so little heed of the effects of coal-cutting machinery in relation thereto. The report of the Commission itself, dated the 27th July, 1871, contains no allusion whatever to this phase of their inquiry; and only one of the five committees appointed by the Commission to deal with different branches of their inquiry, refers to it in any way. This is the committee that dealt with "possible depths in working," and it dismisses the subject of our paper with the remark that "the more general introduction of coal-cutting machines, worked by compressed air conveyed into the mine by pipes, would have some effect in lowering temperature, and would at the same time supersede the labour of hewing, which, from its arduous nature, is that form of labour against which high temperature chiefly militates. Mr. Lindsay Wood states in his evidence that the air discharged from the pneumatic coal-cutting machines is reduced by expansion in the act of escaping to a temperature of 70 deg. Fahr. below freezing, and that the air from one machine is sufficient to lower the temperature of the whole body of air flowing past a working face 1 deg. Fahr. He thinks that as many as seven of these machines might be employed at one working face; but it does not follow that the collective action of these seven machines would reduce the temperature seven-fold, because the principle of accelerated absorption by reduction of temperature again intervenes, and would in a great measure defeat the cooling action of the machines."[1] As a regular thing, it is now found that the use of a single Gartsherrie machine in the Hetton Colliery reduces the temperature at the working face by 2 deg., the pressure of air at the cutter varying from 35 to 45 lbs. Assuming that there is a possibility of employing seven machines in one working face, and that there the atmosphere is reduced in a corresponding ratio, we should find the temperature of the air reduced by 14 degs. In reference to the present, this is perhaps a matter of little moment, because in most of our collieries the means of ventilation are already sufficiently adequate, or may easily be made so. But it is a consideration of the utmost importance in relation to the future of the British coal trade. The Coal Commission of 1869-70 adopted 4,000 feet as the limit of practicable depth in working, and based their calculations as to the duration of our supplies thereupon. But Mr. George Elliot did not think that it would be possible to work coal commercially at a greater depth than 3,000 feet. At that depth a temperature of 100 degs. is met with, whereas the temperature at a depth of 4,000 feet is 116 degs. Mr. L. Wood, although believing that it would be quite competent for men to work coal at a temperature of 98 degs., thinks that at that temperature it would require two men to do the work of one in an ordinary way. There are, of course, cases in which men work in a temperature even higher than this. There are certain operations connected with glass-making which require men to work in an atmosphere heated to from 100 degs. to 120 degs., and at the works of Messrs. Chance, of Birmingham, men work in this atmosphere from 8 to 10 hours three times a week, with an interval of 30 hours between two consecutive workings, without any apparent injury to health. In the stoke-holes of steamers, especially those of the Peninsular and Oriental Company, the uniform temperature is from 100 to 140 degs.; and in the Clifford Amalgamated Mine, in working a valuable lode of copper, men have endured a temperature of 110 to 117 degs. In all these cases, however, the men had ready access to the fresh air—a condition which could not apply to a coal mine at a depth of 3,000 to 4,000 feet. Most medical men are agreed that dry air at 100 degs. Fah. is the limit of human endurance in working, and we cannot, I fear, rely upon our own miners being able to work at so high a temperature. The difference of temperature, therefore, between a depth of 3,000 feet and a depth of 4,000 feet, must be got rid of by some mechanical means before it is practicable to work coal at the latter depth. Coal-cutting machinery will undoubtedly be the chief means to this end. Mr. Brownlees, the well-known engineer, found in constructing the Mont Cenis tunnel that the compressed air from the boring machines always reduced the temperature sufficiently to allow the men to work without any serious discomfort. The application of the same force under well-regulated conditions should produce the same results in the coal mine. At the present time the deepest pit in England is only 2,019 feet. That depth is attained in the Rose Bridge Collieries at Wigan; but in the Charleroi district there is a pit sunk to the depth of 880 yards. We have not, however, any practical experience of the conditions affecting the working of collieries at the extreme depth of 3,000 to 4,000 feet. When it becomes necessary to mine coal at such a depth, we shall probably have to pay much more for our fuel than we did last year, and by that time we shall have learned to practise economy and husband our resources to a much greater extent than we have yet done.

(3.) The next advantage claimed for coal-cutting machinery is a reduction of waste. By waste we understand the small or dross procured in the getting of coal. At the present time, under the most favourable system of working, the ordinary and unavoidable loss is about 10 per cent.; whilst in a large number of cases, when the system of working practised is not suited to the peculiarities of the seam, the ordinary waste and loss amount to sometimes as much at 40 per cent. (Commission of 1869-70, Report C., p. 116.) We shall not greatly err in assuming that the average waste and loss amounts to 20 per cent. In the Hetton Colliery, in a 4 ft. seam, the Gartsherrie machine gives a difference of 16 per cent. in the production of best coal, as compared with hand working; and it has been proved that the proportion of unavoidable waste is not more than 5 per cent., or fully 15 per cent. less than the average proportion of waste by hand hewing. In other words, more than 25 million tons of coal are annually wasted in our collieries by the ordinary process of hewing; whereas it is possible by mechanical labour to reduce that quantity to 7½ millions. In some of our Northern coal fields, and, indeed, wherever coal is adopted for coking purposes, the great bulk of the waste can be utilised in the coking ovens; but where coal is not coked, waste invariably represents loss. Under the head of reduction of waste, it will be well to

[1] Report A., par. XII., vol. I.

notice that coal-cutting machinery can be applied to the thinnest seams, where it is physically impossible or economically unwise to apply hand labour; and a very large additional avoidance of waste may be expected from this source.

(4.) The relief of the miner from the hardest portion of his toil is in itself a recommendation which should lead to the universal adoption of coal-cutting machinery; and I do not disclose any secret, when I say, that it was chiefly with this end in view that the proprietors of the Hetton Colliery have so long persevered with mechanical power. It is often made a just cause of complaint by employers, that their workmen throw needless and vexatious difficulties in the way of introducing improved processes and appliances. But he would be an extremely short-sighted and unreasonable miner who would seek to obstruct or resist this improvement. I have shown that coal-cutting machinery is good for the employer, because it diminishes the cost of production, and gives him a greater command over his men; that it is good for the country at large, because it opens up a prospect of extending our mineral resources, and so prolonging the era of our industrial supremacy; and I have now to demonstrate that it is good for the miner, because it will abrogate his irksome toil. The third proposition is so self-evident that it may almost be called an axiom. It is not necessary for me on the borders of the richest and most productive coal field in England to describe the *modus operandi* of hand hewing. It is the hardest, the most enervating and unwholesome, and, I may add, the most brutalizing work that falls to the lot of man. Stretched upon his back or upon his side, or cramped and huddled up in a space which no ordinary man could enter, the miner pursues his darksome and cheerless toil, until at an age when most other men are in their prime, he becomes a useless, decrepit, and prematurely aged man, stricken with asthma or with some other disease which he will carry with him to his too early grave. Surely if it were possible to remove from the miner the hardest part of his labour, it would be the duty of the coal owner to do so irrespective of the cost. But when, by doing so, he will also benefit himself, and confer permanent advantage upon the country, then I say this duty becomes a bounden obligation, which no man is justified in shirking. The men employed about coal-cutting machinery are so sensible of the relief it gives them, that they are content, as a rule, to take less than their ordinary pay. At the Hetton Colliery, the hewers by hand, getting 2½ tons of coal per man per shift, are paid 26*s.* per score; whereas the men following the machine are only allowed 12*s.* 8*d.* per score. This will not, however, represent more than a difference of 1*s.* per day, the "score" being easier to get by machinery. Miners and mine-owners apply the term "score" to their mode of reckoning, because it is supposed to represent that number of tubs put out by the miners, but there is sometimes more and sometimes less than a score in the number that forms the basis of reckoning. At the Hetton Colliery the score consists of 21 tubs, each containing 8 cwt. When a coal-cutting machine is used, there is little or no excavation by hand. All that is needed is to take up the "bottom coal"—that is, the small quantity that the machine has passed over. The hardest work devolving upon the miners, where machinery is employed, is therefore that of filling the tubs; and this is mere child's play compared with the labour of hewing or excavating.

Having had occasion to refer so frequently to the Gartsherrie machine, I may now be permitted to give you some idea of its form and mode of working: and I do this all the more readily because I believe that up to the present time it has not been described to any technical or scientific society.

The frame of the machine is 6 ft. by 2½ ft. From one of the sides a horizontal jib is distended, round which passes an endless chain, whereon strong steel cutters are fixed. There are altogether nine of these cutters, and they are pressed forward into the coal, when the cutting is about to be commenced, by the distended jib. A chain wheel on an upright shaft drives the endless chain. The machine is self-propelling, and its forward motion along the face is given by an eccentric cast on the bevel wheel, which is fixed on the upright shaft already referred to. The straps of the eccentric are connected with a lever which drives a ratchet wheel. The chain which draws the machine forward is wound round a propelling drum on the shaft of this ratchet wheel, the other end of the chain being made fast in front of the machine. When cutting commences, the endless chain, with the distended jib, moves slowly out of sight under the coal cutting at a rate varying from ¾ ft. to 1¼ ft. per minute. The compressor, which generates the air, is erected at a distance of about thirty yards from the top of the shaft. Its diameter is 18 ins., and the length of stroke is 4 ft. At Hetton, the compressor is built on rather a new principle, and until it has been more completely tested it would perhaps be unwise to speak either of its structural peculiarities or of its results. From the compressor to the mouth of the drawing road the air is carried in six-inch metal pipes, an india-rubber tube taking it the rest of the distance to the machine. In the appendix to this paper you will find a tabulated statement of the work done by the Gartsherrie machine over a period of some weeks at Hetton, under circumstances that were anything but favourable to testing its full capacity. The men were mostly new to their work, and the machine had scarcely a proper length of face to work upon. Three men are required to attend the machine, each of whom is paid at the rate of 6*s.* 8*d.* per shift. Another man is required to "garthe" or look after the chain, which is liable to get out of truth, and he is paid at the same rate, as is also the man whose duty it is to sharpen the cutters, which are brought to bank for this purpose after every shift. The breadth of the cutters is 2¾ ins., which represents the width of the face of the groove made by the machine. In the paper which he read before the British Association in August last, Mr. Firth pointed out that it was far more economical, while it was quite practicable, to work double shifts with his cutting machine. I do not share the opinion that it would be possible to work double shifts with the same machine. Experience has, at all events, proved the contrary. At the Hetton Collieries, after the machine has been at work for nine hours, it takes all the remaining fifteen out of the twenty-four to re-temper the cutter, clear away the coals, and put things generally into order for the next shift. Much, however, yet remains to be done in working out and improving the details of this system.

If I were to speak of other machines now in use at the same length as I have spoken of the Gartsherrie coal-cutter, I should prolong this paper beyond all reasonable limits. I may, however, say very briefly that among other machines which have recently received a good deal of attention, those of Hurd and Simpson, of Wakefield, and of Messrs. Winstanley and Barker, of Manchester, are not the least prominent. The speciality of the former machine is that the air for working it is obtained from a portable compressor, which can be worked in any mine by animal or manual power, and fixed in close proximity to the coal-cutter. The great cost of compressing the air on the surface, and bringing it to the machine in metal pipes, as at the Hetton Colliery, is thus obviated. Winstanley and Barker's machine is designed for "holing" in mines worked on the "wide work" or "long-wall" system. It is driven, like all the others, by compressed air at a pressure of 20 to 30 lbs. per square inch. The cutter holes its own way into the coal, cutting from nothing up to 3 ft., and, in working at the Platt Lane Collieries and the pits of the Ince Hall Coal Company, it has been found that the small coal made by this machine is only 25 to 35 per cent. of the quantity of small coal produced by hand-holing. In hard coal the average rate of holing with a pressure of 30 lbs. per square inch is 25 yards per hour. Another machine now in successful operation is that of Dr. W. J. Clapp, better known as the Nanty-Glo machine. A paper read on this machine before the last meeting of the British Association, stated that it did its work by means of a series of rotating drills, which perforate the coal, and at the same time break down the divisions between the holes bored. There is still another machine patented by Messrs. Gillott and Copely, which has been tried at the Wharncliffe Silkstone Colliery, but with what result I am unable to say. Neither am I able to speak of the merits of the machine brought out some months since by Mr. Simpson, a well-known mining engineer in the West of Scotland.

Before concluding, I may say that the import of the subject to which I have invited your attention this evening may be stated in a single sentence. England's future prosperity must to a large extent depend upon her mineral resources, and these mineral resources will be largely affected by coal-cutting machinery. The experience of the past two years has amply proved that any restriction of, or interference with, our coal supply, is sufficient to disorganize all the springs of industry, and entail more or less of hardship, mischief, and inconvenience on every class of the community. I do not think, then, that I have at all exaggerated the importance of coal-cutting machinery in reference to the future of the coal trade, nor shall I greatly err in predicting that, in the not far distant future, it will become to miners and mine-owners the question of questions, and receive much more consideration than it has ever done in the past.

In an appendix, the author records the particulars of work done by Mr. Baird's coal cutter, starting at East end of Longwall, Second Northway, in Main Coal Seam, Elmore Colliery. These are fully given in the "Proceedings" of the Institution.

THE PARAFFINE INDUSTRY.

By Frederick Field, F.R.S.

THE Society of Arts has inaugurated a new chemical section, which will take special cognizance of industrial chemistry. The first meeting of the section was held on Friday evening, March 6. Dr. Odling, the President of the Chemical Society, was in the chair, and delivered the following address :—

"I have been desired by the council to say a few words at this introductory meeting on the importance of industrial chemistry, but really to do so is to urge upon you a theme which requires no advocacy, I should think, on the part of anyone, and I am afraid it would be as tedious as a thrice-told tale. If we look at the objects with which we are surrounded and consider how very few of them are in the state in which they are presented to us by nature, we shall find that the metamorphoses to which they have been subjected are essentially chemical ones ; that is to say, wherever we find one kind of matter in nature, and somehow or other the matter is turned into another kind of matter, it has undergone a chemical change ; and how very few indeed of the different kinds of matter with which we are surrounded are really in their primitive forms ! When we have mentioned coal, wood, and stone, I mean building stone, we have mentioned almost all. When we consider the gas which, though now gas, was a short time ago in the form of coal, or the glass of our windows which a short time back was in the form of sand, soda, and lime-stone, or if we look at the plaster of our rooms, which was originally limestone but has undergone varied metamorphoses—and more particularly I might direct your attention to the metallurgical industries, especially iron, which was a short time before in the iron stone—all these are instances of the chemical metamorphoses to which we subject the different natural objects, and so change one kind of matter into another. Among all these metamorphoses which are of a chemical nature there are some to which we more particularly apply the name of chemical manufactures. In reality, a brick is a true chemical product ; it was not originally the same matter it now is, but was produced by a change of chemical composition of its elements. But among these more particularly called chemical manufactures, the production of which is conducted in works which are called chemical works, are those performed in so-called alkali works, and I think I need have no hesitation in saying that these works have proceeded to a far greater development in this country than in any other, notwithstanding the fact that among the constituents received and metamorphosed by these works are many which are of foreign extraction, more particularly the pyrites, or other sources of sulphur, and the manganese or other indirect source of the chlorine manufactured at these works. And we see that, in the course of lectures which have been provided for us, three have reference especially to the manufactures which are conducted exclusively at works which are denominated chemical works. We have a process for the manufacture of soda by Mr. Vincent ; another on pyrites, as a source of sulphur, copper, and iron, by Dr. Wright ; and another on the manufacture of chlorine, by Mr. Weldon. Starting from the crude substances, coal and limestone, and pyrites and common salt, we have a production of soda, which will be treated of more particularly in Mr. Vincent's address. Then we have the further manufacture of copper, sulphur, iron, and chlorine, which are the necessary economical concomitants. It is indeed remarkable, at the present day, how much the progress of chemical manufactures consists in the working up of what were formerly waste products. Perhaps we could not have a more singular instance of this than in the utilization to which that class of refuse, which was formerly known as burnt pyrites, is now put. Not only do we obtain from the original pyrites much sulphur which was formerly thrown away on a very large scale, but, moreover, copper and iron, which were also formerly thrown away in the burnt pyrites. And we have also one very remarkable product now obtained from pyrites on a comparatively large scale, and I may say, with regard to the manufacture of copper from pyrites, that the amount now produced—as Mr. Wright will tell you—from a material which was formerly thrown away, constitutes a large proportion of the entire quantity now manufactured in the United Kingdom. But in addition to that, there is a very considerable manufacture of silver now going on, also extracted from these waste pyrites. This extraction of silver from these pyrites, in which it occurs in an exceedingly minute proportion, has an essential interest for chemists in this point of view, that the processes which are adopted for its extraction really resemble most closely the processes which purely scientific chemists adopt in the laboratory. The pyrites is first of all heated with common salt, whereby the copper is converted into chloride of copper soluble in water, and the silver into the state of chloride of silver, which is soluble in the common salt solution ; and not only so, but in this process of removing the soluble copper and the soluble silver from these pyrites, the arsenic and the sulphur, which formerly prevented the burnt pyrites being put to any use, are got rid of, so that what remains is useful in a further stage of the iron manufacture. But with regard to the extraction of the silver, we find how important a knowledge of even delicate chemical processes is, in order to allow the extraction to be pursued with advantage. By the ingenious process of Mr. Claudet and Mr. Phillips, the solution is first of all examined by the nicest chemical means to see the exact amount of silver it contains, by a process rivalling in delicacy that which is pursued in laboratory research ; and having ascertained exactly the quality of silver contained in the solution, the exact quantity of that expensive re-agent, iodide of potassium, which is required, is added to it to precipitate the amount of silver ; and when the iodide of silver is thrown down, the iodine is recovered to be used over and over again, and the silver itself is set free by means of metallic zinc, which forms iodide of zinc, thus setting free the silver. In this way, a considerable portion of silver is extracted. I mention this as an illustration of the remarkably close association which is every day taking place between pure chemistry in the laboratory, and manufacturing chemistry in the factory. Now-a-days we have such out-of-the way bodies, as they were formerly considered, as these different aniline products, as alizarine and chloral, which were formerly barely procurable in the laboratory, now made on a manufacturing scale. On the other hand, we find these different processes of estimation, formerly confined to the laboratory, are now carried on in the manufactory, and thereby such an element as silver is produced by processes which are essentially laboratory processes. In this way it happens that we find many improvements in manufacturing chemistry are now produced by men who have obtained a reputation in other fields. For instance, I need scarcely refer to the names of Hofmann, Perkin, and Nicholson, gentlemen known as scientific chemists and of the highest eminence, before their attention was directed to manufacturing operations, and they realize on a manufacturing scale the results of their laboratory experience. In mentioning them, I ought not certainly to dissociate from them our lecturer this evening, Mr. Field, who was so long and so highly esteemed in purely scientific circles for his admirable researches into a great number of compounds, more especially connected with mineral chemistry, before he devoted his great ability to the elucidation and improvement of the manufacture of aniline dyes and subsequently to the metamorphoses of the bodies which we now use for illuminating purposes in the form of paraffine and ozokerit, and similar bodies.

But while in this way many manufacturers derive a very great advantage from the light thrown on it by purely scientific chemists in one way or another, I do not think we ought to overlook the benefit which pure chemistry derives, on the other hand, from manufacturing operations. I do not mean the mere material gain that purely scientific chemists have enjoyed by the opportunity of examining minutely a great number of bodies, which previously it was almost impossible for them to obtain ; but I think they have gained a very much greater knowledge of the especial subject of their studies—I mean chemical phenomena. We chemists take as our province every change by which one kind of matter becomes metamorphosed into another kind of matter, whereby that which was ironstone, for instance, becomes iron ; whereby that which was sand, chalk, and soda becomes glass, and which takes place wherever one kind of matter is metamorphosed into another ; but, after all, a great number of the metamorphoses which we must study take place in the test tube and small vessels of similar character ; and we are rather too apt, I say, to shut our eyes to those metamorphoses which take place on a large scale around us. Those changes manifest themselves particularly in two forms. We have those by which the different forms of agricultural produce are furnished us by the vegetable kingdom, and by which they are metamorphosed into the animal kingdom. Here we have one great illustration of industrial chemistry—the chemistry by which crops are produced, and by which stock is fed and flesh is made. This feeding of stock and production of crops is one very large function of industrial chemistry, and I would venture to say that any scientific chemist who devotes his attention entirely to what takes place in the test-tube, and who neglects those changes which are constantly taking place around him, has a very imperfect notion of the subject which he professes to investigate. And in addition to these changes thus taking place in natural processes, modified to a certain extent by art, we have three other processes which take place on a grand scale, by which

from some such substances as ironstone we produce metallic iron, from common salt, on the one hand, carbonate of soda, which is applied to the manufacture of glass and other useful purposes, and by which we provide also chlorine in its different combinations, which we apply to so many purposes, more particularly in the preparation of our wearing apparel, and in our linen and fabrics of every description. I think, then, that when we have the advantage of having these industrial subjects brought under our notice by men like our friend here, who are familiar, on the one hand, with the most recondite points of theoretical chemistry, and, on the other hand, with the greatest practical achievements which have been obtained in manufacturing chemistry, it will be of immense benefit to those who wish to study chemistry in its pure aspect, as they will see what can be done on a large scale, and what habitually is done, and what perseverance, assisted by chemical knowledge, has obtained for us. And, on the other hand, it must be interesting to practical men, by throwing out suggestions capable of improvement in various branches of manufacturing art. I think, then, that the Society of Arts has really done a very useful work in bringing together men engaged in the purely scientific pursuit of chemistry on the one hand, and, on the other, men who are pursuing the application of the science with a view to the practical good of their kind. I do not know that I need trouble you with any further remarks, but I have attended here this evening with the greatest pleasure, because I feel how much advantage is likely to be derived by all classes of the community by the discussion of those problems which are so interesting to all, and I would venture to say as much in a purely scientific as in a practical point of view.

The paper then read was :—

On the Paraffine Industry.

By Frederick Field, Esq., F. R. S.

In pursuing his celebrated researches upon the tar obtained from the red beech, Reichenbach discovered in the ultimate portion of his distillates a white translucent substance, to which he gave the name paraffine (from *parum* and *affinis*), owing to the comparatively slight action exerted upon it by most chemical re-agents. The tar was submitted to repeated fractional distillations, and the portions passing over last were mixed with strong sulphuric acid and violently agitated. After standing in a warm place for some hours, the paraffine floated upon the carbonized residue in the form of a pale-coloured oil, which, after cooling, solidified, and was pressed between folds of bibulous paper. By frequent crystallizations from boiling ether, it was obtained as a brilliantly white body, highly plastic and somewhat unctuous to the touch, but not greasy. This interesting hydro-carbon for many years was regarded as simply a chemical curiosity, "and so it remained," wrote Reichenbach many years after its discovery, "a beautiful item in the collection of chemical preparations, but never escaping from the rooms of the scientific man." I remember distinctly having a few grains sent me by Professor Abel, carefully enclosed in a glass tube, to add to my collection of treasures when I was in South America. It is now annually made, as will presently be shown, by thousands of tons.

Before entering into the immediate subject of the paper, viz., "The Paraffine Industry," it may be as well, in a very brief manner, to describe some of the properties of the substance itself. Paraffine is a pure hydro-carbon, having no oxygen whatever, and its analysis has given the following percentage composition :—

	Paraffine from Boghead coal. Gattelly.	Paraffine from Boghead coal. Anderson.	Paraffine from Grey Shale, Addiewell. MacIvor.
Carbon .	85·2	85·15	85·31
Hydrogen .	14·4	15·40	14·50

Paraffine, when pure, is perfectly colourless and translucent; after slightly warming, it becomes highly plastic, and can be moulded with the greatest ease. Hence it differs in some respects essentially from spermaceti, with which it has often been erroneously compared, as well as from stearic acid and other bodies used for the manufacture of candles. From this plasticity, paraffine candles, in warm rooms (if not of a very high melting point) are liable to bend, while on the other hand, those made of sperm or stearic acid, although of a lower melting-point, remain erect. Of course, as has been observed, this very much depends upon the fusibility of the substance, and the harder descriptions of paraffine are always selected for candles which have to be subjected to much heat. Liquid paraffine is very mobile, and can be filtered through paper almost as readily as water itself. It is scarcely acted upon, even by fuming sulphuric acid, unless at very high temperatures, so that it can be purified by this means from many other organic substances, with which it may have been associated, they being immediately charred by contact with sulphuric acid. When submitted for a length of time to the action of chlorine or bromine, chlorinated or brominated compounds are formed, with disengagement of torrents of hydrochloric or hydrobromic acids. Mr. MacIvor, who has devoted many years to the study of paraffine, says that after this body is acted upon by chlorine, it first becomes a gummy looking solid, afterwards a liquid, colourless and transparent, and as the passage of the chlorine is continued, a hard brittle resin is the result. This substance consists of—

Carbon	29·55
Chlorine	66·82
Hydrogen	3·39
	99·76

This gentleman has also remarked that the paraffines having the highest melting-point are those which are most easily acted upon by the gas. Iodine dissolves in paraffine, imparting to it a beautiful violet colour, which becomes brown as the paraffine solidifies ; but the action of this element upon the hydro-carbon is very feeble, no apparent decomposition taking place after prolonged heating for many hours.

By the action of strong nitric or sulphuric acids M. Campion discovered a new body, which he calls "paraffinic acid," and describes it as a bright, transparent liquid, of a very inflammable nature. Strong nitric acid yields a series of interesting compounds, lately studied by Schorlemmer and others. Mr. Fordred informed me some years ago that when paraffine is acted upon by sulphuric acid, to which a few crystals of permanganate of potash have been previously added, the action is so violent that light and heat are evolved, and even at times accompanied by explosion. The best way of trying the experiment is to heat up the acid and permanganate in a tube, and drop a small piece of paraffine in the warm liquid. When they are all three placed together in the tube and heated up, the action is not nearly so violent. Success does not always attend the experiment, but it can be tried. The decomposition convinces us that the word paraffine ("little affinity") is slightly a misnomer.

Paraffine is insoluble in water, very sparingly soluble in alcohol, even when boiling, more so in ether, and exceedingly in naphtha, sulphide of carbon, and aniline. When heated with sulphur at a moderately high temperature it is decomposed, carbon separates, and abundance of sulphurretted hydrogen is evolved. This fact may be of interest to chemists, as affording a ready source of this indispensable re-agent in the laboratory. The two substances, the paraffine being in large excess, are heated together in a flask, when a steady and copious flow of the gas is obtained. We have here a tube containing paraffine and sulphur, and the characteristic action of the gas upon lead salts will be seen by the experiment. With regard to the beautiful translucency of paraffine, which in spite of certain drawbacks has made this body such an unusual favourite as a means of light, Mr. MacIvor informs me that if when melted it is cooled very gradually, and subjected to a slight and steady pressure, it becomes actually transparent, like ice, but that a blow or even a scratch will alter its molecular structure, and cause it to re-assume its normal appearance. As this change is also produced upon re-melting it, however cautiously, that triumph of manufacture in this department of industry, namely, making a transparent candle, is yet in the distance.

The specific gravity of paraffine has been variously stated at ·870, ·852, and ·880, and these discrepancies appear to have arisen from the fact that the experimenters have used different substances in their investigations. Mr. Gelletly has shown that the specific gravity rises with the melting-point of paraffine. Thus paraffine melting at about 90° Fah. has only a specific gravity of ·823 ; at 128° Fah., which may be considered a very good average (rather high, perhaps), it has a specific gravity of ·911 ; and a specimen of an extraordinarily high melting-point (176° Fah.) was as high as ·940, more than ten per cent. above that at 90° Fah.

In attempting to give a sketch of the paraffine industry, which in the space of time usually allotted must necessarily be brief and imperfect, I must be pardoned if many of the names of those who have done good service in this branch of manufacture are omitted, considering that there have been more than sixty patents taken out during the last few years for the treatment of solid and liquid hydro-carbons. To describe them all would be, it may be imagined, a weary task both for reader and listener.

Dr. Lyon Playfair, in the year 1847, called the attention of Mr. James Young to a dark, oily substance exuding from the cracks in the roof of a coal mine near Alfreton, in Derbyshire. This body was distilled, and yielded a pale yellow oil, which deposited, on cooling, small scaly particles, which proved to be the solid paraffine. An establishment was speedily erected on the

spot, and the product from the mine somewhat extensively worked, until it was exhausted, or nearly so. In the meantime, Mr. Reece obtained a patent (1849) for distilling paraffine from Irish peat, and works were erected near Ashby, in Ireland, for its production. It may be remembered by some amongst us, that at that time the natural resources of the sister island were the subject of much discussion, and the enormous amount of peat which is found in many localities was supposed to be, when properly treated, a source of unbounded wealth. It was stated that not only solid paraffine and illuminating oils could be obtained by its destructive distillation, but also acetate of ammonia, and other valuable volatile products. The idea was very popular. A company was started, and although the promised compounds were produced, the expense of obtaining them, the quantity derived from the original peat being so small, led to a commercial disappointment. The following table may give some notion of the amount of materials obtained from the distillation of peat :—

Watery matters	30·614
Tar	2.392
Gases	62·392
Ashes	4·197
	99·595

The watery matters and tar yielding :—

Ammonia	0·287
Acetic acid	0·207
Naphtha	0·140
Volatile products	1·059
Paraffine	0·125

So that 100,000 lbs. of peat would only yield 125 lbs. of paraffine. Peat from the kingdom of Hanover appears to yield more than that from Ireland, 100,000 lbs. yielding rather more than 300. Although in a monetary sense the Irish scheme was a failure, great credit must always be awarded to its promoters. It certainly led the way to other discoveries, and excited a wholesome interest in the hydro-carbon industry. The poverty of the original material operated upon appears to be the only cause of the non-success of the undertaking.

Mr. Young having been successful in his experiments at the Derbyshire mine, but finding his stock of available materials drawing to a close, experimented upon nearly every kind of coal which he considered likely to yield solid or liquid hydro-carbons. With his usual sagacity, he imagined there could be obtained by heating coal gradually by artificial means, such as the application of a low red heat, a product similar to the one naturally produced he had first experimented upon at Alfreton. A highly bituminous coal procured from Boghead, near Bathgate, in the county of Linlithgow, was found to yield large quantities of oil, and a patent was granted Mr. Young in 1850, "for treating bituminous coal to obtain paraffine and oil containing paraffine." An establishment was erected, and he was joined in this undertaking by Messrs. Meldrum and Binney. This Boghead coal, or Torbane-hill mineral, proved to be by far the richest source of paraffine and paraffine oil yet discovered, as much as 135 gallons or 50 per cent. of oil having occasionally been obtained as a product of distillation. Previous to the expiring of Mr. Young's patent in 1864, many works were in operation in Scotland for distilling oil from shale. Dr. Steele, of Wisham, erected several stills at Broxburn, which were eventually sold to Mr. Fernie, who again sold the establishment to a company (the Glasgow Shale Oil Company). There were also the West Calder Works, the Uphall Company, the Oakbank, the Levenside Oil Works, a few names amongst many more, but sufficient to give an idea of the extent to which, in so short a time, the paraffine industry had been developed.

In Wales also, this manufacture was commenced about the year 1861, principally from three varieties of coal, namely, Curley cannel, which yields 30 per cent. crude oil, sp. gr. ·875 to ·890 ; Smooth cannel, which yields 16 per cent. sp. gr. ·925 to ·940 ; and Bastard or Common cannel, an inferior variety. At Leeswood, in Flintshire, the beds of cannel in some places were found to be six feet in thickness. Mr. Hussey Jones, of Leeswood, was, I believe, the originator of the paraffine industry in Wales. His works became the property of Messrs. Fernie and Company, who were defendants in the great suit of Young v. Fernie in 1864, lasting thirty-nine days, a trial still fresh in the memory of some of us, and which occasioned perhaps at the time as much excitement in the technical world, as a certain great trial at Westminster has recently done among the public at large.

Although many chemists had announced the discovery that oils, &c., could be obtained by the distillation of shale and other minerals (see Christison, of Edinburgh, on "petroline" from Rangoon petroleum in 1831, Butler in 1833, Hompech in 1841, Du Bussey in 1845, &c., and many others even anterior to these), Mr. James Young, who was the first to make this industry a practical success and to establish it beyond doubt as a new means of benefiting mankind, must be regarded as the father of paraffine. "It is true," said Dr. Reichenbach, with the generosity that usually characterises a great mind, "that the discovery of paraffine is mine, and I have announced it. To Mr. Young, however, belongs the merit of a second discovery, the merit of having elaborated a method which furnishes a comparatively large supply of this substance, and which is sufficiently remunerative to the manufacturer, a result which I have vainly endeavoured to realise." The professor speaks of a comparatively large supply. The table before you will show how enormous this has become; the figures were given by Mr. Kennedy in his speech at the complimentary dinner to Mr. Hill, late manager of the extensive works at Bathgate :—

Shale used in Scotland	800,000 tons.
Crude oil produced	25,000,000 galls.
Paraffine	5,800 tons.
Lubricating oil	9,800 „
Sulphate of ammonia	2,350 „

To carry out this manufacture about 500,000 tons of fuel were required.

But yet it appears that the credit of first manufacturing solid paraffine on anything like an extensive scale is due to Messrs. William Brown and Co., of Glasgow, and I will read an extract from a letter addressed to the Secretary of Juries of the Universal Exhibition of 1862, by a very eminent London firm :—

"May 20, 1862.

"Sir,—In reply to your communication received last week, requesting to be informed whether there is any peculiarity in the manufacture we exhibit, to which we are desirous of calling the attention of the jury in class 4, we beg to submit the following remarks. We have been using paraffine in the manufacture of candles since March 1855. It was made by Messrs. William Brown and Co., of Glasgow, who were, to the best of our belief, the first makers of it in this country, and by whom we were regularly supplied ; but from the smallness of the quantity produced (only 3 to 4 cwt. weekly), and its imperfection, especially in hardness, we abstained from offering candles made entirely from it, and merely employed it as an ingredient with other materials in the manufacture of the better class of candles. So far back as 1851, we had assisted, in becoming shareholders in the Irish Peat Company, in the attempt to obtain paraffine from the bogs of Ireland. It was not until November, 1856, that they were in a position to deliver paraffine, at which time we received supplies ; and from this source, and a quantity of Rangoon paraffine, we, in March, 1857, manufactured and put in the market for the first time paraffine candles of English make. The price at which they were introduced was 2*s.* 4*d.* per lb."

Mr. Butler has been mentioned as one of those chemists who had experimented upon oils obtained from coal, &c., previously to the patent obtained by Mr. Young, and there is no doubt he found also solid paraffine among his products, as will be seen from the following statement :—Extract from patent granted to Richard Butler, January 29, 1833 (40 years ago, it must be remembered), No. 6,375 : "When the residue of No. 2 distillate is exposed to a low temperature, there will soon appear small flakes of a white, odourless, and light substance, which is a compound of carbon and hydrogen." There can be little doubt, I imagine, that this was paraffine. Nearly all the oil and solid paraffine in Scotland is now made from shale. The last of the Boghead coal was, at the commencement of the year 1872, stacked in a field near Bathgate to the amount of several thousand tons, the greater part of which was destroyed by an accidental fire a few months afterwards.

The following is an outline of the processes employed in Messrs. Young and Company's and other large works for the production of the hydro-carbons :—The shale is placed on the retort and heated, care being taken not to exceed low redness. This is of the utmost importance as a higher temperature would inevitably produce gaseous products. When all the oil has has ceased running, the operation is stopped. This crude product, which is highly impure, is redistilled, producing a certain amount of coke as residue, the distillate being technically known as "once-run oil," a specimen of which is before you. This is agitated with strong sulphuric acid (in the original patent its own volume, but experience has shown that this quantity is not necessary), allowed to settle, treated with caustic soda, and redistilled with steam, the products of distillation being fractioned. The first portion consists of naphtha, which is run in the general naphtha tank, to be ultimately distilled and fractioned to various specific gravities. The second contains the larger portion of burning oil. This is subject to two other treatments with acid

and soda, and again distilled and fractioned; the first portion is placed with No. 1 distillate, and the last portion with No. 3. The third, heavy oil, is cooled and pressed for paraffine scale, of which mention will be made presently, and the expressed liquid treated with sulphuric acid, soda, distilled and fractioned until the desired specific gravity is obtained; and for its ultimate purification is again acidified, allowed to settle, and finally treated with soda. You will see from this, that the crude oil appears to consist of three oils, naphtha, burning, and lubricating oil, the heavy oil being the one that contains the valuable solid product, and that these are separated after treatment with acid by means of distillation. The series before you, and to which your attention is invited at the conclusion of the paper, will show the physical character of the various products. The paraffine scale, which, you may remember, has been pressed from the heavy oil, a specimen of which is in this bottle and still contains much adhering oil and a considerable amount of colour, is mixed with a portion of the naphtha obtained in the process, cooled, and subjected to severe pressure. The oil and softer portions, being more soluble than the solid paraffine, are dissolved, and a cake, diminished in bulk, is taken from the press. This is again subjected to a similar treatment, and if not sufficiently refined for its ultimate purification, undergoes another pressure with naphtha. The loss of this volatile hydro-carbon is somewhat heavy, and to obviate this Mr. Edward Meldrum patented a process, dated 4th June, 1867, No. 1,646, for reducing the impure solid paraffine to a powder, and then introducing or mixing naphtha therewith, after which the mass is subjected to pressure. To give the exact words of the patent, an extract may be quoted :—

"My said invention consists essentially in the purification of paraffine by treating it while in a cold, unmelted state with naphtha, instead, as heretofore, in a melted liquid state. In carrying out my said invention, I reduce the impure solid paraffine to a powder, and then introduce therein sufficient naphtha to make it into a paste or pulp, after which I subject the mass to pressure: or the solid impure paraffine and naphtha may be ground up together, and the mixture may be then subjected to pressure. By repeating three or four times the operation of re-grinding the paraffine to a paste or pulp with naphtha, and then squeezing it in a press, the paraffine can be freed from the heavy hydro-carbon oils with which it is contaminated in its impure state."

This must, it would be thought, save a loss in naphtha; but whether the process has been successful or not, I cannot say.

The cakes thus purified are melted in a still, through which free steam is violently passed, as well as confined steam in a worm at about 25 lbs. pressure, in order to raise the temperature until every trace of spirit is evolved and the condensed water contains no trace of naphtha. The product from the still is mixed with from 3 to 5 per cent. of animal charcoal; heat is applied, and the charcoal allowed to settle. Some finely divided particles remain, however, suspended in the supernatant liquid, and these must be separated by filtration. You will observe on the wall a diagram of a filter employed in the works of Messrs. Young. It consists essentially of a jacketed case kept hot by steam, and lined with a cylinder of wire gauze which is coated internally with flannel, and to make the filtration still more perfect, filtering paper is introduced, so that the paraffine flows through absolutely free from solid particles, and, if pure, as colourless as distilled water. This is run into cakes of various forms and sizes, generally in shallow oblong tins. Messrs. Young, however, prefer the circular shape, as more adapted for transport in casks. Specimens of either form are exhibited.

In the rapid description of the production and refining of solid paraffine from the oils and impurities with which it is associated, it will have been observed that naphtha or other light spirit was employed in its purification, the object being to wash out the greater part of the colouring matter by means of these solvents, and to render the partially purified substance fit for its final passage through animal charcoal. No process can be more successful, as the beautiful results of many eminent houses abundantly testify. But there is an amount of danger attending the operation which many manufacturers have endeavoured to avoid, and some with considerable success. Two or three of the most important it may be as well to mention: first, the patent of Mr. John Fordred, No. 1858, A.D. 1871.

This gentleman, anxious if possible to avoid the use of naphtha or other inflammable liquid, imagined that by kneading, so to speak, crude paraffine scale in a slightly warm alkaline liquor, the alkali would probably form a species of emulsion with the oleaginous portions of the hydro-carbon, and the heat rendering the solid part plastic, the oils and colouring matter could be separated by a rough filtration. The earliest experiments were kindly explained to me by the patentee :—a little bag, such as this, was filled with the crude scale, and after being soaked in warm water for some minutes, was kneaded by the hand exactly as, in lecture experiments, the separation of starch from gluten is effected in the proximate analysis of flour, the starch representing the oil, the gluten the solid paraffine which remains in the bag. After many experiments the apparatus was devised, which is thus described in the patent, and of which a model is before you :—

"In carrying my invention into practice I proceed as follows :—I take say one ton of crude paraffine, having, for example, a melting point of 120° Fah., and melt it carefully in an iron tank, and allow the mechanical impurities, such as tar, sand, and the like, to fall to the bottom; after a few hours' repose I run off the clarified paraffine into a number of flat metal trays, in which it solidifies into cakes, weighing about ten pounds each; these cakes are then placed edge to edge in a long bag of peculiar construction, and submitted to heat in a warm room, or in a bath of warm water, till brought into a plastic condition. When this object has been attained, the bag of paraffine is submitted to the action of the kneading machine, which is supplied with a solution of soft soap in water, made in the following proportions :—Soft soap 10 parts, water 10 parts, previously heated to about 100° Fah. This I call the soap bath. On the machine being set in motion, the oil and colouring matter contained in the crude paraffine will rapidly combine with the soapy liquor, and form a temporary emulsion. I find that any kind of soap soluble in water will answer for the above purpose, but I prefer to use the soft soap of commerce, and in the proportions named. I do not confine myself to the use of a bath of soap and water only, as I find that various other liquors will act upon the paraffine whilst in a warm and plastic condition, such as solutions of the carbonated and caustic alkalis, mixtures of these with solutions of soap, a solution of rosin in alkali, the residual acid of alkaline liquor deposited from acidified hydrocarbon oils after washing or neutralization, and, for some purposes, even warm water itself is sufficient."

The little model on the table will explain the necessary manipulation. The paraffine, previously freed from dross, &c., is placed in the bag, which is tightly fastened to the drum. This drum revolves, and, by means of a little apparatus at the side, can be pressed nearer to a smaller drum underneath, which revolves in a contrary direction. In this manner the oil is squeezed out by a kneading process caused by the action of the spokes of the larger and smaller drums.

A second patent granted to R. M. Letchford and W. B. Nation, No. 890, A.D. 1872, comprises, say the patentees, two objects—first, economy in the materials and labour employed, and secondly, the freedom from danger arising from the use of paraffine oil in the usual methods of refining.

The process is conducted in the following manner :—

"We provide a tank, say about 12 ft. by 6 ft. and 2½ ft. deep, divided by cross partitions into V form cells 2½ in. wide at the top and 2 in. at the bottom. The cells are open at the bottom, as the partitions stop short at 2 in. from the bottom of the tank; their upper ends are 9 in. from the top of the tank; there is a space of about 1 in. between cell and cell; there is a perforated lid or grating to fit into the tank resting on the top of the partitions. A grating with bars 1½ in. apart is suitable. We fit steam pipes (free or closed) into the tank below the partitions. In using this apparatus we run water into the tank to the depth of 6 in. and fill crude paraffine into the cells of the tank, and then secure the lid or grating to prevent the paraffine floating. We run more water into the tank to within 2 in. of the top, and turn on steam until the temperature of the water is within about 10 deg. Fah. of the setting point of the paraffine under manipulation; then we shut off the steam, to allow the heat time to permeate the material. In about an hour we increase the temperature, raising it gradually for about four hours to within 2 deg. of the setting point of the paraffine that was put into the tank; then we shut off the steam and take off the soft portions which have floated to the surface of the water. This being done, we run the water off to the top of the divisions, then melt the remaining paraffine in its cells, and let it stand to cool all night. In the morning the steam may be turned on again to repeat the operation, which is done as often as necessary to obtain the purity and hardness required. It is rarely necessary to do so more than four times: or the process may be conducted by first melting the paraffine in the cells, and then cooling to 2 deg. below the setting point of the material. We then secure the lid, add more water, and float out the soft portions. In either way we finally remove the lid and take out the paraffine from which the low melting portions have been extracted; the low melting portions which have been removed are to be again treated like the crude.

"For obtaining fine degrees of whiteness, when the foregoing operations have been carried far enough, we remove the clean paraffine to a steam-jacketed pan, adding thereto about 7 per

cent. of commercial ivory black in powder, and keep it melted for four or five hours, until the whole of the ivory black is precipitated. We then cast into cakes in the usual way: the ivory black may afterwards be used advantageously in making blacking."

There is one more patent which may be mentioned, among a host of others (No. 3,241, A.D. 1871), granted to Mr. Hodges:—

"The crude paraffine having, if desired, been first separated from rough impurities, is cast into cakes and allowed to cool slowly, so as to form into well-developed crystals. The cakes are then placed on a bed of absorbent or porous material, and are while thus placed exposed to a warm temperature, sufficient to render fluid the more easily melted portions with which the crystallized paraffine is mixed, but insufficient to melt the paraffine. The fluid and more easily melted portions then flow out from between the crystals of paraffine, and into, or into and through, the absorbent or absorbent and porous materials on which the cake rests. The cake—thus freed from the fluid, or fluid and more easily melted portions—may then be treated in any usual method to render it white, or as much lighter in colour as may be practicable; or the process may be repeated until the separation of the harder from the softer portions has been effected as completely as is desired, and then any requisite process for whitening the product may be adopted if needed."[1]

It will be seen that all these processes have for their object the removal of the liquid from the solid hydro-carbons. It would be out of place to give one the preference over the other. Each of the patentees considers, doubtless, that his idea is the best.

The partially purified paraffine, as you will observe from the specimens on the table, is by no means colourless, and upon a closer examination will be found still to possess considerable smell. One method for its further purification may be thus described. Let us take, for example, this material obtained according to the patent of Mr. Fordred. After being melted by free steam to separate any water or alkali which may be mechanically retained, it is poured into a tank and agitated by means of air, with from five to ten per cent. of strong sulphuric acid, the sulphurous acid evolved, resulting from decomposition, is conveyed away by a suitable apparatus. The agitation is carried on for some hours, very much depending upon the nature of the paraffine, and the experienced manufacturer can easily tell when the desired result is effected. Here are various specimens before us of acidified cake, as it is termed, both before the tarry mass has subsided and after remaining at rest for some hours. It will be observed that that which is immediately drawn off is darker in appearance than that which has been allowed to rest, containing as it does a large quantity of black specks, an aggregate of which is seen in the sample of tar in this dish. The best of these products is still, however, far from white, and the acidified paraffine has yet to undergo a further treatment. Animal charcoal, the substance previously mentioned as a bleaching agent, is generally employed. The paraffine is warmed and digested with the charcoal for some hours; the latter is allowed to subside, and the liquid if not quite bright is passed through a filter kept warm by a steam-jacket. But lately, other bleaching agents have been used which are deserving of notice.

A patent was granted to Messrs. Fordred, Lambe, & Sterry, in A.D. 1868, No. 610, for the use of fuller's-earth as a decoloriser of paraffine and other bodies, an extract of which may be quoted—

"Fuller's-earth we also use for finishing the bleaching of the paraffine in lieu of animal charcoal, whatever the previous process of purification may have been. In that case about twelve per cent. powdered fuller's-earth is added to the melted paraffine, which is manufactured at a temperature of about 230° Fah., and well agitated, and after subsidence the clear paraffine is run off. We find that in all our processes, where we have mentioned fuller's-earth as the agent to be employed, we can replace that substance in great part or wholly by marl clay, or other readily-attainable natural substance of like character. The fuller's-earth or analogous substances used in place thereof in any of the ways stated above, may be re-used, and the paraffine remaining adhered may finally be recovered from it by washing with agitation or by other suitable means."

This process is so simple and expeditious that it may be shown as a lecture experiment, and while the earth is being added, and the paraffine brought to the required temperature, and the particles allowed to settle, I will proceed to notice another method of bleaching lately patented by Mr. Arthur Smith and myself, which in many respects obviates certain disadvantages that accrue from the use of fuller's-earth. Fuller's-earth and many other natural silicates are undecomposable even by strong acids, although certain silicates of lime or magnesia or both these bodies are decomposed when the acids are concentrated, forming a gelatinous residue of silica and solutions of the bases. It occurred to us that, by forming artificial silicates and employing them instead of natural as proposed in the previous patents mentioned, these compounds might be employed, and the paraffine or other hydro-carbons separated by the addition of very weak acidulated matter. We experimented with the silicates of lime, magnesia, manganese, iron, and some others, and although all answered admirably, we came to the conclusion that the magnesia salt was the best, a less amount being required to ensure the full bleaching action required. At the first glance, any of these substances, even the lime salt, seems too costly to admit of practical application, but it will be shown presently that this is not the case. The process of manufacture and of the reconstruction of the salt may be illustrated by the row of beakers before you on the table.

No. 1 contains a solution of sulphate of magnesia.

No. 2 a solution of silicate of soda.

When the contents of these two beakers are mixed, there is, you will observe, an immediate precipitate of silicate of magnesia. This is washed thoroughly by decantation. The washing is exemplified in beaker No. 3.

No. 4 contains the substance dried by steam heat.

No. 5 contains the acidified paraffine, which, when liquefied, is ready for the reception of the silicate.

No. 6 was exposed before the lecture to the action of the silicate, which has subsided as a dark mass, leaving the paraffine pure and colourless.

No. 7 contains a quantity of the contaminated silicate, which in No. 8 has been subjected to the action of weak acid, and you will observe three distinct divisions. That on the surface is the separated paraffine; the centre a solution of sulphate of magnesia; and at the base, precipitated silica. The sulphate of magnesia arising from the decomposition of the silicate by sulphuric acid is neutralized and placed in glass

No. 9, and the precipitated silica after washing is dissolved in caustic soda, and removed to glass

No. 10. Nos. 9 and 10 when mixed produce, as you see, the original salt employed, so that really, after the first cost, we can re-form the silicate at the expense only of sulphuric acid and caustic soda.

It is very important to mention that the success of this process depends upon the purity of the salt, and the manner in which it is dried. If the gelatinous mass in that beaker were simply desiccated without previous washing, and the soluble saline body (in this case sulphate of soda) retained, the porous structure, or whatever it may be, of the silicate, would be, so to speak, stopped up, and all bleaching action impeded. And if the washed product were heated to redness, its decolorizing power would always be destroyed. It must be dried at 212° and no higher, and thus the far cheaper and simpler operation of fusing silica with dolomite is inadmissable; the resulting silicates would be valueless. Fuller's-earth, which is simply ground, contains naturally a large quantity of water, and this substance also, if heated to redness, is of no avail in paraffine refining. And yet a more singular fact is this, that although we must have a hydrated compound, no bleaching action takes place until the water is separated. Melted paraffine, as far as my own experience extends, may be agitated either with fuller's-earth or artificial silicate for any length of time, without any perceptible action, at a temperature slightly higher than its melting point. The colour seems to disappear when the water is driven off, as if it took its place, and could not be dissolved from the hydro-carbon, however long the operation might be extended. By this time, it may be hoped, you will be enabled to see the bleaching action of the fuller's-earth in the experiment which was prepared a short time back, and is now awaiting completion.

It must not be supposed that the bleaching action of the two substances that have just been discussed is confined to solid hydro-carbons. Paraffine oil is rendered water-white by digesting it at a moderate temperature, with either fuller's-earth, or an artificially prepared silicate. In conclusion, a few of the applications of this beautiful substance may be briefly enumerated. Independently of its chief employment as a source of artificial light, through the medium of lamps and candles, it has been advantageously applied for other purposes. It has been proposed to saturate gunpowder with melted paraffine, in order to retard its explosive action, if required; it having been ascertained that a smaller sized grain might be substituted for a larger, when subjected to this treatment. The powder is digested with the paraffine, and the excess of the latter removed by steam

[1] This process is carried on upon a large scale at Price's Candle Company, and the manager has kindly lent me a model in order to illustrate its working.

heat. It is a non-conductor of electricity, and has been used extensively as an insulator, in electro-telegraphic science. It has also been employed, when dissolved in naphtha, as a preservative of stone and brick-work, permeating the interstices of the mass, and repelling the action of wind and rain. When melted with india-rubber, it produces a good waterproof compound, which can be applied to wearing apparel. It has been used advantageously for polishing cloths, giving them a fine and smooth surface. Dr. Lawson Tate has made use of paraffine in surgery, employing it as a covering for splints in fractured limbs with very considerable success. The laundress has discovered that by rubbing a small piece of paraffine on a warm flat iron, a beautiful gloss is imparted to linen, and the humble manipulation is much lighted by the ease and celerity with which the iron travels over the clothes, at the same time leaving no greasy stain in its track. The horticulturist has also found that paraffine, when mixed with bees-wax, can be excellently applied in the budding of roses, or the grafting of fruit-trees. Mr. Veally has shown that it is most useful in the preservation of beer barrels, preventing them from becoming foul; and it would be difficult, at the moment, to narrate its many applications, or to speculate upon its future. As paraffine will not dissolve the aniline colours, it may be asked how the beautiful tints are produced which serve to embellish the candles you see before you. The colours are dissolved in stearic acid, which is afterwards diluted with the paraffine, the colour remaining in a mechanically suspended state. If a candle, slightly tinted, is melted, and the liquid passed through bibulous paper, the filtrate is white, and the dye remains on the filter.

The insolubility of certain colouring matters, especially those from aniline, may be employed successfully in determining the freedom of paraffine from stearic or other fatty acids. The specimens before you may illustrate this fact. The first specimen is that of paraffine which has been subjected to a temperature of 212° with rosaniline. The second is the paraffine fused with 2 per cent. of stearic acid, and has, you will observe, a distinct pink colour. The third sample contains 5 per cent. of stearic acid, and the crimson colour is in this instance fully developed. Petroleum and the mineral ozokerit, both closely identified with the paraffine industry, would each demand a separate lecture, and however pleasant it would be for me to speak about these interesting bodies, I feel that I have exceeded the time allowed me, and that your kind attention has already been exercised too long.

Discussion.

Mr. F. A. Abel, F.R.S., said he had been much interested in the lucid account given of the paraffine industry, especially with regard to the purification and the different applications of the paraffine itself. He had himself from time to time become practically acquainted with some of its applications, for instance as a means of retarding the explosive properties of gunpowder. Some extensive experiments were made in that direction in 1867 and 1868, at Woolwich, with different kinds of gunpowders. The grains were immersed in a bath of melted paraffine for a short time, and afterwards allowed to remain at a temperature of about 180° or 200° F., so as to allow the paraffine to thoroughly impregnate the grains, and the result was that the gunpowder became remarkably repellent of water, so that it might be preserved almost under water for some time without any great tendency to change. It also had the effect of retarding the combustion, so that the powder might be made to burn comparatively slowly, but on attempting to obtain a powder so treated which was available for projectile purposes it was found that a very great loss in power was sustained. According to his recollection, in guns of nine-inch calibre it was found necessary to employ 60 lbs. of gunpowder so treated to obtain the same velocity as that given by 45 lbs. of unprepared powder; it was also found that the comparative slowness of the combustion increased the recoil, and largely increased the fouling, because of the non-volatilization of the paraffine, and the retention of a portion of unburnt carbon. On the whole, therefore, the results were not so valuable as was anticipated, and it was found better to obtain the end sought, by increasing the size of the grain, and the density and compactness of the masses. He had also become acquainted with another application of paraffine to the preservation of stone, having been consulted with regard to several processes for preserving the stone of the Houses of Parliament, some of the most promising of which consisted in the application of paraffine in different ways. It was found, however, that when applied after being heated to any considerable extent, the effect was decidedly detrimental, and the stone decayed much more rapidly than when left to itself; on the other hand, when applied with solvents, or at a very low temperature, it furnished more promising results. It had also been found very useful as an application to different fabrics for rendering them water-repellent, and it had been very useful in this way in connection with military equipments—for the preparation of tent cloths, sheets on which soldiers might lie during the night, treating the soles of boots, and for various other similar purposes. The late Dr. Livingstone had written to Dr. Stenhouse saying how grateful he had been to him for sending out some boots and ground sheets which had been prepared in this way. He should have much liked to have had some further information with respect to the peculiar property of paraffine—the great variations in the hardness of the material; sometimes it was almost so soft as to be readily moulded by hand, whilst at others it was comparatively hard. He recollected that in the early introduction of paraffine candles, sometimes they were so soft as to be very readily bent, and he should like to know whether this was simply due to a difference in the refining, or whether there might be different varieties of paraffine possessing different degrees of hardness, with which they might hope to become more thoroughly acquainted by-and-bye.

Mr. Fordred said one property of paraffine which had not been noticed was its great tendency to become discoloured. He had examined very many specimens in different manufactories, but he had never found one which would permanently stand the action of light; it always becomes more or less discoloured in the course of time. A gentleman who had visited the Vienna Exhibition had told him that on mentioning this point to German chemists they said it was utterly impossible, and quite laughed at the idea of obtaining a changeless paraffine.

Mr. Grazebrook remarked that amongst the different uses of paraffine, one of perhaps as much practical use as any, if more generally adopted, was the lining of casks and barrels, for which it was eminently adapted. It was a perfectly pure material, which would not taint, and it had the further great advantage that it prevented the escape of carbonic acid gas by filling up all the pores and joints in the wood, thus fulfilling a great desideratum for the perfection of condition in both beers and wines. He believed it only required to be more generally known to be extensively used for this purpose. One of the great advantages of the Vienna beer was that it was kept in casks which were lined with a preparation of resin, but there could be no doubt that paraffine was in every respect a preferable material.

Mr. Abel said he was reminded by the observation of the last speaker of another application of paraffine which was a very valuable one. It was very difficult of attack by any chemical agent; so much so, that it might be left in contact with concentrated acid without undergoing any change, and this had led to its use as a material for lining the wooden boxes used in the construction of voltaic batteries which contained strong saline or acid solutions. Some years ago, when the manufacture of gun-cotton was first attempted experimentally in this country, the vessels in which the cotton wool was to be converted into gun-cotton consisted simply of soft wood thoroughly lined inside with paraffine, and these were used for several weeks together without any action upon the surface by the strong mixture of the most concentrated sulphuric and nitric acids. It was only when by some slight accident a part of the paraffine coating became removed that the acid got access to the wood, and of course an oxidizing effect was produced at once.

Mr. Field, in reply, said he did not think the difference in the melting point of the different samples of paraffine was as yet understood. He had samples upon the table of paraffine, the melting points of which varied from 130° to 135°, being as hard as it was possible to make it, and there were others with melting points as low as 90°, which were yet exactly of the same chemical composition. He might mention, however, that a paraffine of low melting point had always a lower specific gravity than one which a high melting point. Thus, there would be about 10 per cent. difference in specific gravity between two samples whose melting points were respectively 90° and 140°. It was very remarkable, however, if stearic acid, which melted at 130°, were mixed with paraffine which melted at 130°, the product would be a fusible mass which would melt at 114°; and if you take a paraffine with a lower melting point, say 90°, and mixed it with stearic acid, you get an actual liquid produced which would keep liquid at the ordinary temperature of a room. This seemed analogous to the fusible alloy made of lead and bismuth, which would melt at a point much below either of the metals employed.

A TORPEDO DETECTOR.

CAPTAIN HARVEY, R.N., the inventor of the towing Otter torpedo, lays it down as a primary rule in his tactical instructions for the use of the weapon that an attack upon ships by torpedoes should always be made, if possible, under the cover of night. It is evident that such a rule applies with much greater significance when an attack is made upon ships lying at anchor in a roadstead than under other conditions, and it was with reference to those, most probably, that Captain Harvey arrived at his conclusions, and also only in relation to the torpedoes of the present, which have to be taken to the enemy, and not to those of the future, which we are promised shall be fired from a tube fixed below the vessel's water-line, and which will thus take the form of submarine artillery. The Naval Torpedo Committee have given the subject of attack by torpedo boats at night upon ships at anchor considerable attention, and have proved by experimental practice that in the majority of instances the torpedo attack upon the ship must be successful. The "Monarch," one of the ships experimented upon, was anchored at Spithead, and on one occasion was considered to have been made almost impregnable against any attack by a strong crinoline framework of booms and spars built up round, supplemented by her boats rowing guard round her within hailing distance. The ship had also the advantage of knowing that a boat torpedo attack would be made upon her, and the time when the attack might be expected. Notwithstanding these important advantages in the ship's favour, the torpedo boats—steam pinnaces—burst through the "Monarch's" cordon of guard boats, got over the difficulty of the projecting crinoline spar defence, and struck the frigate with their dummy torpedoes. These results proved that any vessel lying at anchor at night must be fatally deficient in her defensive powers in a want of means for searching with lightning quickness and distinctness the surface of the water to a considerable distance around the ship.

To supply this want effectually, Mr. H. Wilde, of Manchester, some time since submitted to the Admiralty a proposition for the use of one of his electro-magnetic induction machines, fitted with a proper apparatus for projecting the beam of light produced upon distant objects. One of these machines has been fixed on board the "Comet," twin screw gun-vessel at Portsmouth (one of the short and light draught-boats, carrying one 18-ton gun on a raising and lowering platform, on the Armstrong-Rendell plan), and was recently tested under the supervision of Captain Boys, commanding the "Excellent" gunnery establishment, and members of the Naval and War Office Torpedo Committee, with the most complete success.

The following memorandum of the experiments we derive from the report in "The Times":—

On Thursday, February 19, the "Comet" left Portsmouth Harbour for the eastern entrances to Spithead, from the Channel, at about 8 P.M.; but half-an-hour before leaving, a first experiment was made with the machine and its projector lens in throwing the beam of light round the upper part of Portsmouth Harbour. The results were startling. The gunnery ship "Excellent," with her tenders and the boats alongside, and at the boom-ends, the long length of the sea wall enclosing the dockyard extension works, the mud-banks—it being nearly low water—the "Asia" and the vessels about her and further away into Fareham creek, Her Majesty's yacht "Victoria and Albert," the "Glatton" monitor, and the few men-of-war boats moving about between the ships at the time, all stood out with wonderful distinctness as the electric light touched them. But, beyond all the others, the "Glatton," in her French-gray paint, given her as an invisible dress at certain distances by daylight, shone out in weird splendour. It needed no subsequent experiment to prove that a vessel painted in neutral colour must stand out very much more distinctly under the influence of the electric light than another vessel at the same distance, and painted with the ordinary black coating of our broadside ironclads. When the "Comet" subsequently left the harbour and had taken on board the members of the Torpedo Committees off Southsea, she steamed to a position off Brading and the east end of the Isle of Wight and anchored, attacks being then made upon her by two steam-pinnace torpedo boats, from directions, of course, unknown on board the "Comet." When the boats had been away a certain time the electric light was brought into play, its beam sweeping the surface of the water, and in each instance discovering the torpedo boats before they could lessen a mile's distance between them and the "Comet." Discovered at such a distance, their attack, of course, was considered to have utterly failed.

On Friday, February 20, the "Comet" was anchored in Stoke's Bay, near the west end of the measured mile, and buoyed off for the speed trials of Her Majesty's ships. Captain Boys and the members of the Torpedo Committees made a number of experiments with the light, upon which official reports will be made, as will also be done with the experiments conducted on the previous day. If we knew, which we do not, the exact details of all these experiments, comment upon them here would be out of place as anticipating the reports to be yet made by Captain Boys and the members of the committees. What was evident to all afloat and on the look-out for the trial of the new light on the nights of Thursday or Friday was that its power was immense, and of this we may speak freely and yet briefly. On Friday, as on Thursday, no boat could approach the light within a mile without being at once discovered, and the grey or white painted steam-pinnace was always much more prominently and longer in view under the light than the other in its coat of black paint. In a boat at 2,000 yards distance from the "Comet," and with the beam of light brought to bear upon the boat, "The Times" could be read with the greatest ease.

It now only remains to describe Mr. Wilde's apparatus as fitted by him on board the "Comet" for producing and projecting this light. It consists of two parts—an electro-magnetic induction machine for producing the electricity, and an arrangement for regulating the light produced by the current and projecting it upon distant objects.

The electro-magnetic induction machine is founded upon a new and somewhat paradoxical principle discovered by Mr. Wilde—that magnets and electric currents indefinitely weak can produce magnets and currents of indefinite strength. The machine consists of a circular or cylindrical framing of cast-iron, round the interior of which are arranged a number of electro-magnets at equal angular distances from each other. A cast-iron disc is mounted on a driving shaft, running bearings fitted to each side of the framing, and carries a number of armatures revolving before the electro-magnets. A slight charge of magnetism is imparted to the electro-magnets before the machine is used for the first time by transmitting a momentary current through the wires surrounding the iron cores, or by touching their extremities with the poles of a permanent magnet. This initial charge is always retained by the electro-magnets, and is the basis of the augmentations of the electricity and magnetism produced by the rotations of the armatures. As the armatures revolve they become slightly magnetized in their passage between the poles of the electro-magnets, generating weak currents in the insulated wires surrounding them. These currents are transmitted by means of a commutator through the wires surrounding the electro-magnets, so as to increase their magnetism, until, by a series of actions and reactions of the armatures and electro-magnets on each other, the magnetism is exalted to the highest degree of intensity and the most powerful currents of electricity are produced. A small fraction of the current thus produced is sufficient to sustain the power of the electro-magnets, while the major portion of the current produces the light. The machine on board the "Comet" is 28 in. high, 34 in. in length, and 21 in. in diameter. Its weight is 11 cwt. About four-horse power is required to drive it a velocity of 600 revolutions per minute, and this driving power is obtained on board the "Comet" from the fly-wheel of the small engine that raises and lowers the 18-ton gun and its platform. At this velocity the current will fuse an iron wire 6 ft. long and 0.05 in. in diameter, and will burn "carbons" half an inch square. In this machine the alternating current is used for producing the light; past experience in light-house illumination having proved it to be greatly superior to the direct or continuous current, since it has the important advantage of consuming the carbons equally, and thus always retains the luminous point in the focus of the optical apparatus used in connection with the machine. The alternating current also dispenses with commutators, and the destructive spark on the rubbing surfaces is also avoided when the light may be accidentally extinguished, or when the circuit becomes broken from any other cause, Copper-wire conductors are laid from the machine along the "Comet's" deck, from the position of the machine over the engine room to the fore part of the vessel, for the transmission of the electric current to the apparatus where the light is regulated and projected from. All the arrangements on board the "Comet" in this respect have been made to render the light available for naval purposes, whether as a torpedo boat detector or otherwise, and with this view a simple mechanical regulator arrangement, worked by the hand, has been substituted for the delicate mechanism by which the carbon poles have hitherto been automatically adjusted. The carbons as they consume are made to approach each other by means of a right and left-handed screw, the screws being made to act independently of each other, so as to allow of the adjustment of the carbons to the focus of the optical apparatus used for projecting the light. The regulator, with its carbon points, is placed in the

focus of a catadioptric lens, which parallelizes the divergent rays of the light into a single beam of great intensity. The lens, with the regulator, is pivoted horizontally and vertically on the top of a short iron column fixed on the forecastle bulwarks of the "Comet." The box holding the lens and regulator with the carbons is thus well elevated above the bows of the vessel, and the beam of light, by the action of a quick screw adjustment, may be directed to every part of the horizon, and cover any object within the vertical angle of its range. As the carbons only require regulating once in two or three minutes, this is effected by the man in charge without any interruption in the movements for directing the beam of light.

Such is the "Wilde electro-magnetic induction machine," and the nature of the work it did at the trials described, so far as it is necessary to enter upon this in a paper written only to explain its powers as an electric light for the Navy. It is almost superfluous to observe, however, that any ship of war having one of these machines on board, would find its light-producing powers of inestimable value for other purposes than its employment as a torpedo vessel or boat detector in an anchorage at night. The cost of working such a machine is a not unimportant item in any official consideration of its usefulness. Mr. Wilde in his official communications with the Admiralty, has estimated the cost of producing the light from his machine on board the "Comet," exclusive of the driving power obtained from the vessel's engine-room, at only 4*d.* per hour.

THE VITALITY AND VICISSITUDES OF SUBMARINE TELEGRAPHIC CABLES.

A QUESTION now being asked by electricians, and gradually brought to the test of practical experience in various ways, is—what is the *vitality* of a submerged electro-telegraphic cable; what (in the language of actuaries and insurance offices) is its "expectation of life," the probable number of years that it will maintain its efficiency for its intended purpose? Let the answer to this question be what it may, a telegraphic cable must continue to be one of the greatest marvels of science and practical art. No familiarity with its appearance, its constituent materials, its manufacture, its submersion, or the *modus operandi* of its daily life will ever remove the sentiment of admiring wonderment with which it is regarded by any person of ordinary intelligence. We say "daily life," for it really is almost a thing of life.

Just consider what it means, and what is the work which it performs. A rope varying from ¾ in. to 1½ in. in thickness, is built up of four or five materials. The most usual type of cable, such as those which are every day conveying flashes of intelligence between England and America, beneath the waters of the Atlantic Ocean, contains in the centre a group of seven small copper wires, packed closely together, so as to form in effect one wire a little more than an eighth of an inch thick. It is literally true that all the messages, all the impulses that can be translated into a language of symbols, pass through this central cluster. Whether the message relate to the price of barreled pork at Cincinnati; to a rise or fall in oil at Petrolia; to the ruling rates for bread-stuffs at Chicago; or to a brush with the Modoc Indians in the Yellowstone Valley—whether it amplifies into the proceedings of a democratic convention; a women's rights ferment; a raid into the Canadian dominion; or the annual message of the President to the Legislature—in all cases, the little centre of the little rope is the medium of communication. All else is a shielding, an armour, a protection. The copper must not touch water, else its insulation, its power of retaining the electric current without lateral waste, would be deteriorated. Therefore, as a necessary precaution, the centre copper is coated with insulating gutta-percha or india-rubber (usually the former), substances remarkable for their non-conductibility of electricity, their refusal to permit a transverse passage to this subtle agent. The better to ensure this result, the gutta-percha is applied in layers, intervening with other layers of a tarry composition. The wire centre, by the time it has received this gutta-percha garment, is about three-eighths of an inch thick. Then comes a greatcoat of considerable strength and thickness. Good iron or steel wire, say one-tenth of an inch in thickness, is closely bound with twisted strands of the best hemp or New Zealand flax, sometimes saturated with tar, sometimes left in its untarred fibrous state. Finally, several of these covered wires are coiled round the gutta-percha coil, so as to present a compact rope-like appearance. If for the shore-ends of a cable, which have to bear the chafing action of rocks, shingle, and breakers, the jacketed rope may have a thickness of two inches and a-half; but the main portion of the length is generally an inch or an inch and a-quarter in diameter; in some examples rising to an inch and a-half, in a few limited to three-quarters of an inch.

This is literally all; this is *the* cable, the channel through which the electric message travels. Of the exquisite electro-magnetic instruments used on shore we do not here speak; they are concerned in producing the electric current itself, modifying this current so as to produce mechanical movements, causing these movements to denote words or symbols of words, and interpreting these symbols at the other end of the line; but the travelling of the impulse through thousands of miles in the twinkling of an eye depends on the cable itself. We repeat, there is nothing in scientific discovery or mechanical invention more wonderful than this. Much as science has been popularized by the able summaries which from time to time appear, the marvels of the present subject have not yet been brought down to general comprehension. Setting aside the bits of humour which occasionally appear, concerning the enquiries of simple persons whether a letter, a pair of gloves, or a parcel, can be sent by electric telegraph; setting aside these, which are sometimes authentic, at other times made up for the sake of joking—there is ample room for speculating and guessing as to the nature of the agent which really does travel through the cable. Let not an enquirer be humiliated at his ignorance. To this day, none of our scientific men, however eminent, can say undoubtedly what electricity is; they only know that it is a *something* which is roused into activity by various means, and can propagate this activity through any length of metallic wire, with a rapidity only a little less than that of lightning. The laws that govern the production of that which (for want of a better term) we call the activity of this something are gradually being discovered; as are those connected with the continuance of the activity in the form of an invisible current, together with the influence of different substances in their treatment of this current—some acting as conductors to let it pass, some as non-conductors to refuse it a passage. These laws, we say, are being discovered by the untiring exertions and watchful intelligence of electricians and telegraphists; but they leave us nearly as far as ever from a true and clear answer to the question—what *is* electricity?

We cannot wonder that every fact connected with the material and manufacture of telegraphic cables should undergo strict scrutiny, with a view to ascertaining whether the best is done that can be done, and in what direction a remedy should be sought for proved defects. There must be no "leap in the dark" here. A cable 2,000 miles in length, and costing something like £400 per mile, is not a plaything to be trifled with. One slight fracture, and down it goes to the bottom of the ocean, in water perchance twenty or thirty times as deep as St. Paul's Cathedral is high—that is, the broken ends may be at that depth, trailing along the oozy ocean bed To search for these ends of so small a cable at such vast depths beats hollow the proverbial achievement of searching for a needle in a bundle of straw; you can see and handle the straws one by one, but the bottom of the ocean is far beyond the limits of visibility. The two problems—to make the cable strong enough to bear its unavoidable burthen of mechanical difficulties, and sensitive enough to fulfil the electrical conditions of telegraphic transmission—require to be constantly borne in mind. Those who are responsible for the efficiency of the work have to ask themselves what shall be the diameter of the cable; of what metal shall the central wires consist; shall they be one thick wire, or a clustered group of several; shall the insulating coating be gutta-percha, india-rubber, or a combination of the two; shall the core thus prepared be shielded with a jacket of stronger wires, or with one of fibrous character; if of iron or steel wire, shall these wires be separately coated before being twisted round the core as a rope; shall the coating be of Manilla hemp, New Zealand flax, or some other fibrous yarn; and finally, shall this fibrous yarn be saturated with tar or some other preservative composition? Not one of these questions can be neglected; seeing that the efficiency and durability of the cable are materially affected by the matters here indicated.

VICISSITUDES IN THE MANUFACTURE OF THE CABLES.

These general observations will prepare us for others of more specific character, which will help to show the reader how numerous, varied, delicate, and complex are the conditions necessary for the due rendering of the required services by submarine telegraphic cables.

Sir James Anderson, managing director of the Anglo-American Telegraph Company, has put before the public an able summary of the results of his experience concerning the vitality and vicissitudes of submarine cables. A better authority could not be found. Some are more versed in electricity as a science; some

have more to do with the mechanical processes of manufacture; but it was he who, as Captain Anderson, commanded the "Great Eastern" when the Atlantic cable was safely laid in 1865. He was knighted by the Queen in the following year, and has ever since been intimately acquainted with all the proceedings of the Atlantic Telegraph Company—now known (after amalgamation with other joint-stock bodies) as the Anglo-American Company. Responsible for many thousand miles of cable, which have gone far to absorb seven millions of money, he has every motive for testing those conditions which may truly be designated the "life, character, and behaviour" of these delicate and costly products of man's ingenuity. Some years earlier a scientific committee of the Board of Trade had been appointed to enquire into all the circumstances connected with electric cables, their manufacture and their submersion, with a view of obtaining rules for the guidance of those who planned extensions of the system. The committee comprised the names of Wheatstone, Galton, Fairbairn, Edwin Clark, Latimer Clark, and Varley—all men experienced on this subject. The report of this committee, published in 1861, has been of great value to later companies and electricians. Fifty cables had been submerged down to that time, no less than 8,000 miles of which lay useless at the bottom of the sea—in the Atlantic, the Mediterranean, the Red Sea, and the Indian Ocean—having come to grief in some way or other. Why mishap had occurred to them, was one of the main objects of the committee's enquiries, as a means of providing against such contingencies in future. Sir James Anderson says, in his paper, that ten or twelve years of further experience had led him to confirm most of the conclusions arrived at by the committee.

Let us now notice briefly some of the contingencies and vicissitudes in cables, affecting their vitality or usefulness.

First, there is the central copper wires through which the electric impulse flashes. Sir William Thompson, who stands in the foremost rank of electricians, has discovered that some kinds of copper are no better than iron as conductors, and that many cables have been rendered "dumb" by inattention to this matter. It results from his experiments that the copper ought to be of so pure a quality, that a wire one-tenth of an inch thick would have as much electro-conducting quality as an iron wire a third of an inch thick. Even if the copper be originally good, it becomes deteriorated by anything approaching to unskilful manipulation. The copper wire for the first Atlantic cable, for instance, had been so often coiled and uncoiled, so often exposed to the heat of the sun and to changes of temperature, that it became lowered in quality before even the insulating covering of gutta-percha was applied. We may remark that the first manufacturers of telegraphic cables made the central conductor of one thick copper wire, but this was found to be rather too brittle and unyielding. Sir Charles Bright and Mr. Latimer Clark devised a mode of making the conductor something like a hollow cylinder, the pieces fitting telescopically end to end. But the plan most generally adopted is to twist several thin wires round one in the centre; sometimes as few as three, usually as many as seven in all, forming a copper twine which is both strong and yielding.

Then, the copper ought to be exactly in the centre of the core, no nearer to one gutta-percha side than to another. This has not always been ensured in practice, for it is difficult of attainment except after long experience and with very perfect mechanical appliances. Sometimes the copper has been almost visible through the thin film of the insulating material which covers it on one side, there being more than enough thickness on the other side. In such a case the electric current soon weakens the film, and at last finds its way through, to the inevitable ruin of the cable.

Next is the inquiry whether the gutta-percha covering of the copper is the best insulator that can be used. There is no direct evidence at present that this substance decays, or loses its non-conducting power when in contact with water; but it undergoes deterioration when kept quite dry and exposed to strong light. India-rubber bears light and dryness better, hence some of the cable-making companies prefer this material. Considerable success has been attained by the company which adopts Mr. Hooper's plan. He coils tapes of pure india-rubber round the copper conductor, and coats this with a composition of india-rubber and oxide of zinc; an outer envelope we shall speak of presently. Nevertheless, gutta-percha is still the material most generally employed, as possessing (all things considered) a preponderance of favourable qualities. It may possibly be that the choice of material will, in future, be somewhat influenced by the geographical and climatic position of the sea or ocean in which the cable is to be discharged; seeing that any additional warmth in the water affects the insularity of the two substances in different degrees.

Supposing gutta-percha to be selected, those who are responsible for the efficient working of the cable have to determine whether the core can safely be left to bear the action of sea water, sharp rocks, and the numerous other perils that threaten sub merged cables; or whether it ought to have a protecting jacket. One thing is incontestable, that strong, heavy cables are better than light, thin ones, supposing them to be equally well manufactured; a few advantages may be attributed to the latter, but the balance is in favour of the heavier cable. This affects the question immediately before us, seeing that a cable cannot be covered with a jacket of substantial iron wire without being rendered somewhat ponderous. A lighter cable would suffice if a tranquil submersion to the smooth bottom of a deep sea could be insured; but as this is problematical, the cable ought to be strong enough to provide for contingencies. During the Crimean war an electric cable was laid from Balaklava to Varna; it was only half an inch thick, and had no covering to the core. This cable rendered good service for a time, but became dumb after a few months, and had to be replaced by a better. Several lines of unprotected gutta-percha core were submerged in the Mediterranean in 1869; every one of them failed within two years, owing (as is believed) to a gradual decay in the insulating power of the unprotected gutta-percha.

If, then, the core ought to be protected, of what nature should the protector be? Some of the early light cables were clothed in hemp, without any external wires. This was not found to be sufficiently protective. Mr. Newall made a hemp-covered cable in 1859, and submerged it between Candia and Egypt; but the hemp was eaten off by the *teredo* in a very short time, and the cable so much weakened that it could not be raised for repair. Tarred hemp, without any external metallic jacket, has been used; but telegraphic engineers have arrived at a pretty general conclusion that a compact sheathing of coiled iron wires is desirable, with a layer of hemp between it and the gutta-percha. But do not these wires themselves require protection? This question is now answered in the affirmative. The first Red Sea cable, covered externally with light wires, but the wires themselves unprotected, became so rusted in a short time that it could not be lifted for repairs. One advance in the manufacture, therefore, was to coil hemp round each individual wire before the wires themselves were coiled round the gutta-percha core. But is even this sufficient? Let the annoying little *teredo* answer. "There is one kind which destroys the hemp in a few months, and is then satisfied to fix itself upon the gutta-percha, and remains there. Cables have been recovered from depths of 1,400 fathoms with all the hemp eaten away, and the core pitted with these marine animals. The recovery is then only possible by the strength of the external wires."

In the india-rubber cables made on Mr. Hooper's system, the core is clothed in a jacket of vulcanized india-rubber, while exposed for some hours to a temperature of 250° Fah. Some of the sulphur (always an ingredient in vulcanized india-rubber) passes through the composition, and partially vulcanizes the core itself. The gutta-percha cables, as we have described, go through a different ordeal; but it is equally true in both cases that telegraph engineers do not now leave the core unprotected.

Thus it is, then—the outer coating of good wire protects the core, the hemp coiled round the wire protects the metal, and the tarry composition imbibed by the hemp protects the fibres; besides which, the strength of the iron is necessary to enable the cable to bear the strain to which it is subject. The copper centre, scarcely thicker than a stay-lace or boot-lace, becomes clothed in garments which swell it out to the thickness of an inch or more. Thin iron wire will not suit here. A cable somewhat faulty in the core may still be worked if the wire jacket be sound; but should the wire be thin it becomes eaten away with rust in certain parts, and then breaks up into short sections. A thicker wire would ward off this peril; but, as we have said, the wire itself needs protection from salt water, marine animals, marine vegetation, &c. Although not universal, the practice is general, of saturating the hempen yarn with a mixture of pitch, tar, ground silica, or other ingredients, as a waterproof and insect-proof covering for the wires; and, besides this, the wires themselves are usually galvanized before receiving their fibrous overcoat. Silicated bitumen is found to be better than tar as a saturating liquid. We may mention that though the external wires have in some cases been as many as eighteen in number, ten is the limit now generally preferred. For the thick shore-end cable, as a means of obtaining a little more flexibility, each component wire is a strand of three thinner wires.

Any defects in the manufacture are sure to tell their tale when the cable gets into practical use; and that some defects or other are likely to occur, may easily be seen when we watch the processes at the cable factories. First, there is the making of the copper centre, the all-important channel through which the mysterious electricity flows. To make this clustered group of seven, a thin copper wire is dragged by steam power through a hole in a circular table; six other wires, each uncoiling from a revolving drum, are made to twist round by the

rapid rotation of the table; and thus the six become coiled round the one to form a copper cord or twine. Different manufacturers vary the modes of combining the progressive motion of the middle wire with the rotatory motions of the other six, but the main principle is the same in all. Then comes the insulating covering. Telegraphists, as stated above, have not yet finally determined whether gutta-percha or india-rubber is the better substance to employ: seeing that they have to take into account the market price, the facility of working, the non-conducting or insulating power, and the durability; but down to the present time gutta-percha has been, and still is, more generally adopted. This remarkable substance is crushed to fragments, macerated in hot water, churned and washed, boiled, sifted, and squeezed; it is so treated as to expel from it every foreign substance, and render it as smooth and homogeneous as possible. This is important, seeing that if there be present any substance which is a conductor of electricity, it may ruin the whole cable. The gutta-percha, as a kind of soft brown dough, is forced by hydraulic pressure through a die; the copper conductor is at the same time drawn through the centre of the same die, and the two emerge together, the copper coated with gutta-percha. This is repeated three or four times over through a series of dies gradually increasing in bore, whereby the thick cord or small rope augments in diameter. It might seem that one application of a substantial coating would suffice; but the repeated drawing condenses and consolidates the material, while the copper is kept more nearly in the precise centre of the mass. To secure adhesion and insulation, the cord is coated with a pasty compound after each coating of gutta-percha; many kinds have been devised, known as "Chatterton's compound," "Bright's compound," &c., consisting of non-conducting substances combined in various proportions. Chatterton's compound, very extensively used, consists of one part Stockholm tar, one resin, and three gutta-percha. So far as conductibility of the centre is concerned, and insulating power of the sheath, the cord (say 4-tenths of an inch thick) might now be used as an electric cable; but, for reasons already stated, a strong jacketing of steel wire is necessary. The wires for most of the long cables are usually ten in number, individually of the thickness known in the trade as No. 13. Each wire is separately coated with a layer of (say) tarred Manilla yarn, and the whole are tightly coiled round the core by means of steam-worked revolving mechanism. As a further precaution, there is interposed between the core and the wires a fibrous sheathing, sometimes of jute-yarn tanned in catechu, sometimes of hemp or flax variously treated. A complex whole, truly. Six copper wires surrounding one in the centre, four coatings of gutta-percha, three or four layers of composition between the coatings, a garment of jute-yarn, an armour of twisted iron or steel wires, an overcoat of Manilla hemp, and a saturation of tar as a final waterproof. In order to give precision to our conception of this matter, it may be well to state the exact weight and dimensions of one of the best cables ever yet made—that which was laid from Brest to America. There are 400 lbs. of copper wire per nautical mile, 400 lbs. of gutta-percha, 234 lbs. of fibre wrapping round the core, 1,589 lbs. of iron wire, and 1,091 lbs. of saturated hemp or jute covering—3,714 lbs., or 33 cwts. 18 lbs. in all, giving a diameter to the cable of 1·134 in.

One failure in any one of the processes above described, one defect in any one of the substances employed, might ruin the cable, or at any rate entail great expense and loss of time before repairs could be effected. Hence the most scrupulous watchfulness. The eye alone is not trusted; the cable is tested throughout the whole process of manufacture, to ascertain whether electric impulses pass readily through it. Besides the workpeople in the employ of the cable-makers, telegraphic engineers in the service of the purchasing company have to be on the watch. There may be minute defects in the core, or a slightly defective splice in joining the pieces end to end, trivial in themselves, but grave sources of future disaster. It has become an established rule that every portion of the cable shall be repeatedly tested during the successive manufacturing processes, and every defective piece cut out and rejected. We might suppose that many splicings, end to end, would injure either the conductibility of the copper or the insulating power of the sheath; but so skilfully is the work now done that a spliced joint is as good as any other part of the cable. The testing is done in water and under pressure, in order to imitate approximately the external conditions under which the cable will afterwards work. The first Atlantic cable was not tested under water, for fear of rusting the thin iron wires with which it was covered (that cable was not much more than half-an-inch thick); hence many defects were not discovered till too late for remedy, and the cable came to ruin. The same was the case with the cables first laid down in the Red Sea and the Indian Ocean; they were not tested under water during the making, and many hundreds of thousands of pounds were lost by the existence of faulty portions undetected till the cables were submerged and set to work. Another point is that, with the exception of testing, a cable should be kept as undisturbed as possible. Sir Samuel Canning, who has had lengthened experience as a telegraph engineer, dwells on the importance of keeping the cable quiet from the time of its manufacture to its immersion in the sea; every process of coiling and uncoiling injures it.

Vicissitudes in the Submersion of the Cables.

Cable making, as we have seen, is subject to very numerous contingencies, some likely to end in disaster, others in which disaster is a certainty, and others which occasion much anxiety and trouble, although there may be no considerable monetary loss. They are, however, as nothing compared to the perils of the cable during the process of laying. A ship must take it on board and accommodate it with stowage room, without interfering with the sailors and their regular duties. The cable must be so coiled as to yield readily to the process of uncoiling when wanted. It must be made to travel over the side of the ship without knots or entanglement of any kind. It must descend directly through thousands of feet of water, until it rests on the sea-bottom, oozy or rocky as the case may be. The ship must sail or steam onward over the ocean just as fast as the cable unwinds from its coils; seeing that any strain arising from inequality of motion would snap the cable at once. The pitching or rolling of the vessel must be watched with unremitting attention, lest the slender thread which dips down into the tossing waves (for a slender thread it is comparatively) should give way. Meanwhile, the cable must not be pierced, crushed, bruised, or maltreated in any way: so sensitive is it to anything that will interfere with the free passage of the electric impulse through it.

Let us see what were the difficulties which had to be encountered by those who undertook the duty of laying the first Atlantic cable. It was not the first submarine cable, but it was the first of great length, and most of the real difficulties had to be met and conquered for the first time.

In 1854 Mr. Cyrus Field and Mr. Gisborne undertook the bold work of forming a company and obtaining the money for laying a submarine cable, about 1,700 miles long, from Ireland to Newfoundland; Lieutenant Maury sounded and dredged the sea-bottom, while Professor Morse devised a system of telegraphic signalling. In 1855 Mr. Brunel, Mr. (now Sir Charles) Bright, Mr. Brett, and others, were taken into council, to aid the enterprise in various ways. In 1856 an "Atlantic Telegraphic Company" was formed, and a capital of £350,000 subscribed, in shares of the very unusual magnitude of £1,000 each; while liberal subsidies were obtained from the English, British American, and United States governments. The cable was manufactured—the core by the Gutta Percha Company, the external armour of wire by Messrs. Glass and Elliott; the quantity made was 2,500 miles, to allow for slack and other contingencies; and the weight was about a ton per mile. In 1857 all was ready by the month of July. There being at that time no ship in the world large enough to carry 2,500 tons of cable, in addition to all the usual machinery and stores, the cable was divided into two halves; one carried in the "Agamemnon" (lent by the English government), the other in the "Niagara" (lent by the American government). They started from the quiet harbour of Valentia, on the west coast of Ireland, on August 7th. The "Niagara" began paying out her portion of the cable; the cable uncoiled from the hold, passed round a central block, wound round and among a series of grooved sheaves, passed over another sheave overhanging the stern, and so down into the sea. Carefully as the engineers did their work, experience had not yet taught them to do it carefully enough; an entanglement led to a breakage on the very first day; a splice was made, and the ship went on again. On the 11th, when 280 miles out, snap went the cable a second time, and the loose end went down in 13,000 feet depth of water. The engineers had not the means for fishing up the cable from so profound a depth; and so the expedition returned, every one on board disheartened.

The year 1858 saw a revival of the project. The company raised more capital, ordered more cable to be made, obtained improved paying-out and grappling machinery, and were offered the use of the same ships as before. The plan adopted this time was for the two ships to steam out to mid-ocean, splice the ends of their two half-cables, and then separate; the "Agamemnon" laying the cable thence to Ireland, the "Niagara" to Newfoundland. They started on the 10th of June and spliced their cables on the 25th, but on the 26th occurred a break; on the 29th two breaks; and there lay 144 miles of cable along the bed of the ocean, wholly severed from the other portions. Back came the "Agamemnon" to Ireland for more cable, rejoined the

"Niagara" in mid-ocean, and recommenced the laying on July 29th. All went on surprisingly well. The two ships reached their respective destinations on the 5th of August, and telegraphic greetings were exchanged between the two countries on the 6th. But alas! the international joy was short-lived. The electric working of the cable became weaker and weaker every day, until at length it became permanently dumb on the 1st of September. The company had gained experience at a tremendous cost. It became evident to the engineers that the cable had suffered injury during the winter of 1857-8, when deposited in tanks in Devonport dockyard; the repeated coilings and uncoilings of a rope not much more than half-an-inch in diameter had injured alike the conductibility of the copper wire and the insulating power of the gutta-percha. The splicing arrangements had answered well enough. In effecting this important process, the copper wires are laid bare for a given length at each end and filed to a given angle or slope; the filed ends are soldered, then bound and braced with fine wire, then coated with new gutta-percha and composition, and finally the outer armour of hemp-covered iron wire restored.

The year 1859 was a gloomy one for the company, and so was 1860. The money was all spent; the cable was pronounced to be too thin and weak; numerous improvements were needed in almost every part of the arrangements; and the Stock Exchange was shy in the matter. In 1861 and 1862 many experimental researches were made by scientific and practical men; in 1863 the plan for a new cable was resolved upon; in 1864 new capital was subscribed, a contract was made for a new cable ($\frac{11}{10}$ in. diameter instead of $\frac{6}{10}$), and the mighty 'ship "Great Eastern" was chartered to effect the laying. The cable was 2,300 miles long, and weighed no less than 4,100 tons.

And now we come to 1865. The "Great Eastern" was remodelled in the interior, and fitted with three immense circular iron tanks, the largest of which was 58 feet diameter by 20½ feet deep. The cable, in three portions, was coiled round and round till the tanks were nearly full to the top. On the 24th of June the mighty ship steamed out of the Medway with nearly 14,000 tons of cable, cable-tanks, and coals. On the 23rd of July she started from Valentia, to commence her cable-laying voyage to Newfoundland; attended by the "Terrible" and the "Sphinx." A mishap occurred on the 24th; the cable became dumb, and great trouble and anxiety had to be borne before it was discovered that a small piece of iron—an intruder—was sticking into the cable and destroying the insulation of the gutta-percha sheathing. On they went, and prospered till the 29th, when another misbehaviour of the cable led to another laborious inhauling and examination, and the discovery of another bit of iron wire driven right through the cable. A third instance of the kind presented itself on August 2; and all on board gloomily speculated on two theories for explaining these mysterious intrusions of bits of wire—a "cable-assassin" theory and a "cable suicide" theory. While endeavouring to rectify the injury, snap went the cable, and the end sank in 2,000 fathoms water. Then for the first time engineers knew what it is to grapple for an inch-thick rope at a depth of more than two miles beneath the surface of the sea. A grapnel or five-armed anchor was lowered at the end of a wire-rope until it reached the ocean-bed; and the "Great Eastern" steamed to and fro athwart the line of cable, performing an act of dredging such as had never been performed before. Three times, between August 2 and August 11, did a grapnel catch hold of the cable; three times did the hopeful crew haul up the grapnel with its load; three times did the wire rope break, and let go grapnel and cable to the bottom. There were no more grapnels, no more grapnel-ropes; and the "Great Eastern" had to return again to Ireland, leaving 1186 nautical miles of telegraphic cable lying uselessly on the bottom of the Atlantic Ocean. Dr. W. H. Russell, who was on board, and acted as historiographer of the expedition, declared that one and all of them nearly cried with vexation at such a humiliating extinction of their hopes.

The year 1866 dawned gloomily indeed for the Atlantic Telegraph Company. There had been four expeditions—one in 1857, two in 1858, and one in 1865; and the result was—4,000 miles of cable lost, temporarily at any rate. At great sacrifices the company raised new capital and constructed a new cable, not differing much in form from that of 1865; but the paying-out and grappling apparatus were materially improved. No less than 2,730 miles of new cable were provided. Three kinds of grapnel were provided; *five-pronged*, to hook hold of the cable on the sea-bottom; *holding*, to lock it in one of the prongs so firmly that it could not escape; and *cutting*, having a sharp edge to each prong for severing the cable if necessary. Quite a formidable cable-fleet started from Ireland on the 17th of July—the majestic "Great Eastern" being attended by the "Terrible," "Medway," "Albany," and "William Corry." The result was magnificent. Not only was the '66 cable successfully laid, but the '65 cable was grappled for, raised, and joined to a sufficiency of new cable. The 1st of September witnessed the wonderful fact that telegrams were sent to England through both cables, and congratulatory messages exchanged between the Queen and the President.

We have nothing to do here with the later history of the Atlantic Telegraph Company and its cables. We are treating of the vicissitudes of cable-laying, in whatever oceans they may occur; and we will now further illustrate the subject by an instance of much more recent occurrence.

Of all the troubled existences of submerged cables ever yet recorded, that of the Jamaica and Panama line has been the most eventful and extraordinary. The real facts have only been made public recently. One of the cable-manufacting firms, bearing the somewhat lengthy name of the "India-Rubber, Gutta-Percha, and Telegraph Works Company," took the contract for the manufacture of the cable, to form part of the system of the West India and Panama Telegraph Company. The two companies have been terribly at loggerheads concerning the responsibility for disaster. It is not for us to decide between them; but it is quite fair that the actual makers of the cable should place on record the unprecedented difficulties which they have encountered in laying the cable, and the indomitable determination that these difficulties should be surmounted at any cost. Let us tell the story in the words of the chairman of the company at the recent annual meeting; he spoke as one who was officially conversant with all the facts, and was sensibly alive to the losses which he and all the shareholders had incurred. We may premise that Colon is the name of the port on the Atlantic side of the Isthmus of Panama, the port and town of Panama being on the Pacific side. "The Colon shore end was laid by Sir Charles Bright from the 'Dacia,' on the 14th of October, 1870. On the 27th, after 340 miles had been well laid towards Jamaica, there was a breakage in 800 fathoms; and the weather was so heavy that grappling, though continued, was unsuccessful. On the 2nd of November the ships had to break off. The expedition then returned to Jamaica, having marked the site of the cable-end with buoys. There had been great sickness on board the 'Dacia;' and we lost some of our cable hands by yellow-fever and other diseases during or just after the first Colon affair. It was therefore determined to leave that unhealthy sea for a time, and to lay the cables along the other West India Islands, which occupied the expedition until February, 1872; then the 'Dacia,' shortly afterwards accompanied by the 'International,' which we had despatched to help, went out again to grapple for the cable between Jamaica and Colon. Mr. Edward Bright, Captain Hunter, R.N., and Captain Beesley, of the 'International' were then in charge of the expedition; and the two ships actually remained grappling throughout the spring, summer, and autumn of 1872, in the heats and storms of the Caribbean Sea. A constant current of three knots an hour, and a trade wind, then steadily and strongly set to the north-west; no ship can grapple against both current and wind; so that after a run, with current and wind, across the cable-line, the ships had to hand up grapnels and work back against current and wind to leeward of the cable line, and begin again. You will still fail to appreciate all the difficulties of the work, even when I tell you that in parts of that sea under which the cable lies there are numerous large coral reefs not marked on the Admiralty charts; that between two soundings you may pass over a submarine fall or cliff 1,000 fathoms or 6,000 ft. deep; and that in the spot where the cable was broken there were 1,600 fathoms depth of water. Just consider for a moment. 1,600 fathoms are close upon 10,000 ft.—about three times the height of Snowdon, and more than twice the height of Ben Nevis. Imagine grappling at that height for a rope at the bottom, even if there was only air between, and you could see the nature and arrangement of the surface at the bottom; but substituting water for air, imagine groping without the aid of sight, through 10,000 ft. of boisterous sea constantly in motion, to catch with a hook a rope lying at the bottom, and when you have caught it to raise it to the surface."

Considering that it occurred in a business speech to business men at a busy hour, this is very good word-painting, bringing the extraordinary operations before us with much vivacity. But we are only part of the way on the story yet. "This was how our ships were employed for six or seven weeks together at a time, and then running to seek shelter from a fierce storm, to obtain provisions and coals, or to give respite to their exhausted crews. From March to August, 1872, the 'Dacia,' with Mr. Edward Bright and Captain Hunter, was grappling for the Colon cable even at 2,200 fathoms. In August, Sir Charles Bright rejoined the expedition; Captain Hunter left, and the 'Dacia' was obliged to return home. The 'International' had begun grappling for the cable in April, 1872, and continued off and on to the end of December. Sir Charles Bright was in command

from August till December; and under his command the broken end of the cable was picked up in mid-sea, joined to a new cable, laid to Jamaica, and found to work. So far from being content with this result, when Sir C. Bright, in testing the cable, detected a fault 140 miles from Colon, he immediately set off to repair it. He grappled the cable at once; but the weather was so heavy and the sea so rough that the machinery gave way, the cable broke under a severe strain, and with a sore heart he had to turn back and give up the enterprise for a time. The season was past, the 'International' was foul, and there was no course open but to bring her home. We were not even then discouraged. Having refitted and re-equipped the 'International,' we sent her out again in March, 1873, under the charge of Captain Hunter, R.N., who had, however, first to repair one cable and lay another between Florida and Cuba; in less than four days he picked up the one in 900 fathoms, and, after repairing it, laid down the other. Owing to the state of the weather he could not begin to grapple for the Colon cable until the 5th July, 1873, and then he could only grapple intermittently; but after five weeks' persistent toil he hooked the cable on August 10th, in 1,750 fathoms, or 10,500 ft., and brought it up within 200 fathoms. No doubt in so doing he had to raise from the bottom at least ten miles length of cable; it could not bear the strain, and broke in two places, leaving some two miles in the middle, which were hauled on board ship. Again he grappled for the cable end towards Jamaica, and on August 25 secured it, spliced on a new length, laid it towards the broken Colon end, and then cut and buoyed it while he fished for the Colon end; at the first grapple he hooked it and brought it safely up. But the weather was so rough that, before he could join the two ends, he had to let the Colon end go down again and mark it with a buoy. When he got weather to work in again he found one buoy had got adrift with one end of the cable which had been parted by the violence of the seas; and on the 8th of September he picked up the Jamaica end, this time in 1,800 fathoms water, and then ran on and picked up the Colon end; but before the two ends could be united the Jamaica end parted under the heavy strain. This happened once again; but on the 12th of September Captain Hunter secured the Jamaica end at the first cast, bringing it up on board, uniting the two ends, and laying the entire cable safely at the bottom of the sea. But even then his end was not attained, for on returning to Jamaica and testing the cable, a fault was discovered close in shore; there had been an earthquake; the shore end had been laid bare though buried 6 ft.; and the cable was injured further out upon some coral beds not marked in the Admiralty charts. With great exertion all these difficulties were overcome, the cable picked up, repaired, and relaid, and on the 7th of October, 1873, the Colon-Jamaica line was at length completed, and found to be in fine working order."

Cable Ships and Cable Fleets.

Not the least curious part of this interesting subject is the gradual formation of a cable fleet, comprising a considerable number of well appointed vessels.

The first point to mention in connexion with these ships is that sailing vessels were speedily found to be unfitted for the work to be done; nor is the matter much better when a steamer is employed to tow a sailing ship, the latter containing the cable. The two vessels have not enough steerage way when met by strong head winds; they pay out too much "slack," thereby wasting a considerable length of valuable cable. It is difficult under such circumstances to steer a straight course; while sailing ships possess no power of being readily stopped when a fault or accident occurs. This was all the more serious when, in the early days of the system, the best method had not yet been ascertained of paying out the cable and regulating the speed with which it is allowed to pass over the stern into the water. It used, moreover, to be supposed that the water of the sea has very little motion below a depth of 50 fathoms, and that 100 fathoms denoted absolute quiet. It is now known, however, that there are exceptional localities where there is motion at a depth of 500 fathoms. The first Falmouth cable, and that which was laid between the Dorsetshire coast and the Channel Islands were chafed and destroyed even at this depth. Both currents and anchorage must as much as possible be avoided. It is now an admitted principle that no cable should be laid without first obtaining an accurate survey of the approach to the shore and landing-places, accurate soundings along the whole intended route, and as much knowledge as possible of the nature of the sea-bed. Whatever may be the thickness of the cable adopted, an extra thickness is always given to those portions which necessarily run through less than 400 fathoms of sounding. There is one cable, the French Atlantic, which dips down to the almost incredible depth of 2,760 fathoms, or 14,560 feet—upwards of two miles and three-quarters; and yet, once laid, such a cable is very safe. Whatever may be the difficulties arising from such causes, they are enhanced by the use of sailing ships, with the comparatively clumsy apparatus which they contain. When the cable was being laid from Toulon to Algiers, the sailing ship was run into by a French ship going to assist her, and the cable was lost. When the line was laid to Corsica, it took five days to run 70 miles; the ship came to anchor every night, and held on *by the electric cable* itself till daylight! In laying the Sardinia cable a common ship's windlass was used to haul in for examination, instead of special apparatus. As a consequence, the cable snapped. On a second attempt of the same expedition, the leading ship went in the wrong direction; the cable was run out before land was reached; the tank ship held on while assistance was sent for; but before this could arrive, a storm came on, and the cable broke in 400 fathoms.

In the second place, it is now felt that a vessel, a roomy steamer, should be built expressly as a cable ship. No alterations can be made in a ship constructed for war, for passengers, or for general merchandise, that would make it adequate for receiving the enormous tanks in which three or four thousand tons of cable are stowed. The "Great Eastern," the largest ship in the world, supplies the only exception; and as this is very costly to maintain and use, it is suited only for the longer and more important voyages. In recognition of these facts, the "Hooper," belonging to Hooper's Submarine Cable Company, was built last summer by Messrs. Mitchell, of Newcastle-on-Tyne. Everything was planned and constructed with express reference to cable-laying. The ship is 350 feet long, 55 wide, and 36 deep, of 5,000 tons gross register, with engines capable of working up to 2,000 horse-power. It has three tanks, each 53 ft. diameter by 30 ft. deep, so constructed as to form component elements in the framework of the ship, giving and receiving strength thereby. It carries a small transverse screw in addition to the usual screw running lengthwise of the ship, as a means of obtaining slight lateral movements when necessary in paying out and hauling in. It carries many thousand fathoms of grappling cable, each consisting of seven strands, and each strand having seven wires separately covered with Manilla hemp. For paying out from the tank the cable passes over and under four grooved pulleys, then over a drum 6 ft. in diameter, and then over a paying-out wheel near the stern. The pick-up apparatus near the bows comprises every new improvement which experience can suggest. This fine vessel is now (March, 1874) engaged in laying cables near the Brazilian coast of South America.

In the third place, it is recognized that ships are necessary to watch and maintain the cables as well as to lay them. Telegraphic engineers are no longer satisfied with the mere submersion; they know that a cable sometimes becomes dumb even without breaking, and that a lamentable waste of time occurs in waiting till a ship can be sent out from England to effect repairs. When any one company owned only a short length of cable, a repairing ship was regarded as too costly an affair to be maintained; but when several joined their interests by amalgamation or working agreements, the expense became bearable in being distributed over a larger area. Such is the case at the present day. Repairing or maintaining steamers, well provided with paying-out, picking-up, splicing, and other apparatus, electrical testing and telegraphing instruments, and a moderate supply of new cable of various thicknesses, are stationed in various parts of the Atlantic, Indian, and other oceans, ready to render aid whenever disaster befalls any of the submarine cables.

The repairing ships here mentioned are the means of making known a singular diversity of actual or probable mishaps. One of the cables submerged between England and Spain was fractured by a submarine landslip. Lightning is known to have destroyed three cables—not directly, but indirectly through striking land wires first; but this kind of injury is now warded off by the use of lightning guards at the junction of the land wires with the submarine cable. A very odd source of trouble was detected in connexion with a small cable stretching from the Hampshire coast to the Isle of Wight; a bullock fell overboard, got entangled in the cable, and broke it. Still more remarkable was the fate of a cable laid from the Persian Gulf to the mouth of the Indus. A repairing ship, sent to rectify some breakage or interruption, found great difficulty in hauling up the cable; a whale was at length fished up, with the cable twisted two or three times round his huge body. No one save Neptune—and perhaps not he—could tell what the whale and the cable had been about.

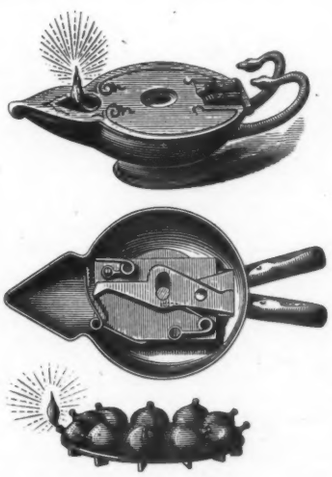
An important subject is now engaging the attention of pilots, sailing-masters, and captains of ships generally, viz., the rule of the road at sea. How can an ordinary vessel know a cable-ship? can it be compelled by law to yield precedence to the

latter? and how can avoidance of interruption best be insured? Cable ships, especially at night, are often a puzzle to the captains of other ships; while the latter are still more frequently a source of anxiety to the former. Cable-laying has often to be accomplished in seas busy with navigation; and a cable-ship can with difficulty get out of the way, either when paying-out or picking-up. To make a détour as a means of avoiding another vessel, a paying-out ship would waste much cable, and would perhaps meet with a rocky instead of a smooth sea-bed. Still worse would any change of course be when a cable is being picked up for repair. As has been aptly remarked, a cable-ship so employed is practically moored. Those on board "could only get out of a ship's way by cutting the cable; and when the latter is a heavy one, such as those generally used in shallow water, this is an operation which cannot be performed by a few blows from a carpenter's hatchet. But it is when a cable has just been hauled up to the surface by grapnels, or has just been secured by chains previous to cutting it, that the position of a cable-ship is most hopeless; for the cable cannot well be cut by a hatchet, while it takes some time to file through when hanging by chains that cannot easily be let go. In such a position a cable-ship requires to be avoided by all vessels that are under way." It is understood that the Board of Trade is considering the feasibility of establishing some "rule of the road," and some system of special lights, for cable-ships.

Of the matter broached in our opening paragraph, the real vitality of submarine electric cables, science cannot yet speak. So few cables have been wholly free from disaster that the problem has hardly yet had fair play. If a well-constructed, safely-laid, and carefully-preserved cable is steadily worked year after year, will the copper wire lose any of its conducting sensitiveness, or the gutta-percha or india-rubber sheathing any of its insulating impenetrability? The answer to this question, involving the saving or spending of millions of money, is written in the future.

THE AUTOMATIC TAPER LAMP.

THERE has recently been invented, says the American "Science Record," a taper lamp for the instantaneous production of a flame or light, which is accomplished by simply pressing together the two handles shown in the upper figure of the annexed engraving. The interior mechanism is shown in the figures below. Each tube consists of a little ball of fatty material from which protrudes a short match. These tapers are all set on a rotating plate, under the lamp cover, and are so arranged that,



when the handles are pressed together, the plate rotates, and one of the matches rubs against the inside of the case near the spout or opening in the cover, which rubbing or friction ignites the match and communicates fire to the ball, which thereupon burns, producing a light that lasts from five to seven minutes. This is a very curious as well as a useful little example of mechanism.

THE BLOCK SYSTEM.[1]

WHAT is understood by the block system is the absolute preservation of a definite space between the trains running on a line of a railway, so that each train is protected from the one immediately following it by this interval. The term "block" system, however, thus applied is not strictly correct. It should rather have been the "space" system, as contradistinguished from the "time" system, which is the system by which trains are maintained apart by an interval of time. The application of the term probably arose from the necessity of "blocking," or pinning the handle of the signalling instrument over in the earlier systems, and it has now become so deeply rooted in the phraseology of railway working that it is not at all likely ever to be eradicated. The principles of the block system may be generally stated to be the maintaining of trains apart upon the same pair of rails, secure from collision, by a certain and invariable interval of space. The practice of the system depends for its success upon the degree of perfection to which the apparatus used in carrying it out has been brought, the simplicity of the operations its working involves, the exactness of the rules and regulations devised for its working, the discipline maintained in enforcing these rules and regulations, and the carefulness with which the duties of the signalmen are performed. The principles of the system are absolute and unvarying, not so, however, its practice, inasmuch as on several lines of railway, where it has been adopted, different apparatus and different regulations are employed in carrying it out. This arises from the circumstance that several electricians have taken up the question and have worked it out to a practical issue, each in his own way, with a greater or less degree of success, and each railway has been working upon its own experience. The germ of the block system is traceable to Sir W. Fothergill Cooke, who developed the theory into practice as far back as 1842. Subsequently, about the year 1843, Sir W. Cooke practically applied the block system in the Queen-street tunnel, Glasgow. The next application of the principle was made by Mr. Edwin Clark, who adopted what is now known as the permissive block system on the London and North-Western Railway. This was a system intended not so much to increase the security of travelling as to increase the capacity of the railway for the transmission of its rapidly-increasing traffic. It consisted not in maintaining an absolute interval of space between following trains, but in checking the speed of a following train if it trenched too closely upon its predecessor. The permissive system may possibly expedite traffic on a line, because, under certain conditions it permits a relaxation of the more stringent rules of blocking, but it takes away that absolute security to trains afforded by the block system in its integrity.

Another step in the development of the block system to produce signalling apparatus for working it was made by Mr. C. V. Walker, who introduced his method upon the South-Eastern Railway. The leading feature of Mr. Walker's improvement was the introduction of a bell signal, Sir W. Cooke's system being based on the principles of the needle telegraph. Judging from results, the most perfect development of the block system is that worked out by Mr. W. H. Preece, and adopted on the South-Western Railway, of which line Mr. Preece was formerly and for many years the chief electrician. In place of the telegraph signals of Sir W. Cooke and the bell signal of Mr. Walker, Mr. Preece has visual signals, which are placed in the signal box, and which are an absolute reflex of what occurs outside, and, in some cases, out of the signalman's sight. His method of working the electric signals is precisely similar to that already adopted in working the out-door signals, and with which every signalman is so well acquainted. He in no way depends upon electric telegraphy for correctness of working, his system being based upon electric signals. Instead of telegrams passing to indicate whether the line is clear or blocked, a permanent signal is made behind each train to protect it from any following train, and what is more, the signalman does not make his own danger signal, but it is made by the man at the signal station immediately in advance of the moving train, and he, moreover, alone has the power of taking it off. Two other names should be mentioned in connexion with the development of the block system, and they are those of Mr. Tyer, who has done much good in this connexion, and Mr. Spagnoletti, whose system is used on the Great Western and Metropolitan railways.

Numerous attempts have been made on various lines to introduce a perfect and trustworthy system, and that opinions are far

[1] From "The Times" of March 11th, 1874.

from unanimous as to which is the best plan is evident from the fact that scarcely two of our leading railway companies adopt the same method. Every main line emerging from the Metropolis has a certain and distinct system of its own, so that it would be an almost interminable task to describe the working of the block system as it is represented under these varying aspects. It will be better to select one example for illustration, the selection being based upon the degree of success the system selected has attained, that success being not a matter of opinion, but one of fact, as proved beyond question by figures. Immunity from accident is the one great test of the system, and by this standard alone can it be fairly judged. Taking, then, Captain Tyler's report to the Board of Trade, upon the accidents which occurred on railways in 1872, it appears that on the North-Eastern Railway, with a length of 1,337 miles, the number of train accidents was 36; on the London and North-Western, with 1,539 miles, 35; on the Great Western, with 1,402 miles, 16; on the Great Northern with 578 miles 8; on the Great Eastern, with 833 miles, 6; on the London, Chatham, and Dover, with 147 miles, 4; on the South-Eastern, with 327 miles, 4; on the Metropolitan, with 13 miles, 3; and on the London and South-Western, with 648 miles, 3. Two out of the three accidents on the South-Western line are stated to have been caused by errors on the part of the engine-drivers, while in the third—in which a brakesman was killed—it is supposed that the engine-driver was under the influence of drink and failed to shut off steam sufficiently soon to avoid the collision. The accidents—each of which occurred at a station—were, therefore, in no way referable to the inefficiency of the block system, but to inattention to instructions on the part of the company's servants, the effective working of the block system being solely a question of discipline. Moreover, in the Board of Trade Report for 1871, no train accidents appear to have occurred on the South-Western Railway. Hence the conclusion that the block system has been more successfully developed and is more effectively carried out on this line than on any other, appears to be corroborated; and this, among other circumstances, justifies the selection of the apparatus there used for description.

The block system of signals was first introduced by Mr. Preece, on the South-Western Railway, at Exeter, in 1860, since which time it has been gradually extended over the greater portion of the company's lines. The total length of the South Western lines at the close of last year was 648 miles, out of which 480 miles were already protected by the block system, while 60 miles more were in course of being fitted, and in time the whole of the South-Western system will be fitted on this principle. The apparatus by which the signalling is carried on is a beautiful combination of mechanical and electrical principles—a combination which in practice has been found to produce the most unerring results. It fulfils in a very direct manner the following conditions, which may be taken as the leading requirements of the block system, viz.,—it supplies, first, a communication between two stations by which notice of the approach, progress, and departure of trains and their character is given; by it, secondly, a "danger" and an "all clear" signal is afforded for protecting and guiding the trains on each line of rails; thirdly, it gives the signalman at one station the sole and complete control over the signal at the other station, and renders it impossible for him to interfere with or alter the signal in his own box; fourthly, it insures the proper acknowledgment of every signal, and that the acknowledgment shall not only imply the due receipt of the signal sent, but that it has been correctly understood and properly acted upon; fifthly, that the apparatus employed shall be unaffected by those atmospheric and cosmical causes which are so injurious to telegraphs generally; and, lastly, it provides that any derangement of the apparatus, or accidental delivery of a false signal, either by the signalman himself or by the mechanical interruptions to which wires are liable, shall at once indicate danger, and thus produce safety. The first requirement is met by the use of an electric bell, so constructed that every current of electricity transmitted through the wires produces one blow upon it. By varying the number of currents sent—or, in other words, by the signalman pressing the piston of a small sounding apparatus, technically termed a key, a given number of times, a code of signals is formed by which the approach and departure of a train and the nature of the train are simultaneously announced at the next station. In the next place, it is required that there shall be two signals—one to protect the down-line and the other the up-line. The apparatus for this purpose consists of a semaphore placed in the signal box, and which, both in form and action, is a counterpart of that exhibited to the driver of the train on the line. In its normal condition the arm of the instrument is raised to "danger," in which position it is maintained by a small counterweight. By means of a current of electricity the arm is lowered to "all clear," and will remain down so long as a current flows. Directly the current ceases the arm flies up to "danger" again by the action of gravity, just in the same way and at the same moment that the arm of the ordinary line semaphore rises. The signal is under the sole control of the signalman towards whom the train is approaching.

The instrument by which the semaphore is lowered and raised is called a switch, from the similarity of its construction, appearance and action, to the switch handles for working the signals on the line. By moving the handle over from one side to the other, it places the battery in connection with the line wire, and thereby causes a current of electricity to flow, which lowers the signal. The principle by which the semaphores are actuated is the attraction of an electro-magnet, which simply does what the pull upon a wire effects on the line. This apparatus completely fulfils the third condition of a perfect signalling description. The signalman at one station has the sole control over the signal at the station next below him, and he cannot interfere with or alter his own signal by any movement of his own apparatus, nor can any accidental disturbance of his instruments affect it. The "All clear" signal in his box can only be given by the signalman at the station above him. Next, let us consider the fourth condition, which requires that every signal shall not only be acknowledged, but that the sender shall know that the receiver understands its import. In order to show how this condition is complied with, it will be necessary to explain the process of manipulating the signals between two stations; and here it should be mentioned that the two stations need not necessarily be passenger stations, which on some lines are a considerable distance apart. Now, as the fundamental principle of the block system is that no two following trains shall be allowed to proceed in the same direction upon the same line of rails, between two signal-boxes at the same time, it follows that if these boxes were placed at the stations only, in some cases the traffic would be seriously impeded. The line between the stations is therefore divided into sections, signal-boxes being placed at the beginning and end of each section, so that two trains cannot be on the same pair of rails within any section at any one time.

To illustrate the working of the block system clearly, it will be best to give the following example of actual practice. The observations upon which it is based were made at Southampton and Bishopstoke and the intermediate signalling stations. The distance between the above-named places is five miles, and the intervening space is divided up into seven sections, each of the first four being about 400 yards, and the last three about a mile and a half in length. The shortness of the sections is necessary here in consequence of the exceptionally heavy traffic passing over the line, as well as on account of numerous sidings and of the Dorchester branch, which is connected with the main line at two points. Omitting, for the sake of clearness, all the intermediate signal-boxes save one, let it be assumed that the observer is stationed in that one—say the Northam Junction, which is situate between Southampton and Bishopstoke. The first indication received by the signalman at the junction that a train is approaching him from Southampton is the warning signal, which is given on the bell by the signalman at the signal-box next below him between the junction and Southampton, and which indicates that the train has entered the section under the control of the intermediate man. This signal implies, "Train coming; look-out;" and it enables the signal-man at the junction to see that the line is clear for traffic, and that both the electrical signals at the box below the junction and the out-door signals on the line at the junction are lowered for the train to pass. The line being thus cleared for its approach, the entry of the train into the section under the control of the signalman at Northam Junction is indicated by another signal on the bell from the signalman in the intermediate box. The electric semaphore arm and the out-door arm corresponding with it are then at once raised behind the train to protect it from being followed by any other train, and these signals remain up during the time the train is running through the section. When the train has passed out of the section the clearance of the line is indicated—first, by lowering the arm of the electrical semaphore, and next by a separate and distinct signal upon the bell. The out-door arm is then lowered, and the section is thus prepared for the second train to pass over it. The approach of every train is thus announced and its passage protected. It will therefore be seen that trains moving under the block system have their way prepared before them, and their passage carefully guarded behind them.

In order to insure accuracy it is imperative that every signal shall be acknowledged, and no signal is considered complete until it is acknowledged. It is, of course, very essential that the man at one box shall know, not only that the arm has been lowered or raised at the further box, but that the man at that

box has seen that signal and has acted upon it. This is effected by an automatic arrangement which renders a mistake simply impossible. It consists in a change in the direction of the current sent, which is effected by the instrument itself, entirely independent of the signalman, so that when he answers a signal the automatic action of the signal causes him to indicate the fact of the instrument having operated correctly by signalling back the words "On" or "Off," which are made to appear on an indicating instrument. This repeating arrangement is one of the essential features of a perfect block system.

Northam Junction is a point where the Weymouth trains enter the main line between Southampton and London. At all such points it is necessary to introduce an additional protection to prevent the possibility of two trains approaching the junction at the same time. Messrs. Saxby & Farmer's interlocking arrangements, recently described in "The Times," have been introduced to prevent the possibility of the out-door signals giving false instructions to the drivers, so that when the signals upon the main line are lowered those upon the branch line are locked. Precisely the same arrangement has been introduced by Mr. Preece into his block system, so that when the main line is cleared for the passage of a main line train, the branch line is locked and blocked.

In order to insure the proper protection of the train it is necessary not only that the signalman should know that the electric semaphore at the distant station has acted properly, but that the distant signal which he himself works has also acted properly. This signal, though within 1,000 yards of his box, may be out of sight, and in foggy weather is almost sure to be beyond his view. At night, again, it is more frequently hidden from his sight; hence it is very necessary that he should be able to ascertain whether it is in proper action. An electrical apparatus is therefore added to these signals, which indicates to the signalman that they have acted rightly, by day by simply actuating a small miniature signal—semaphore or otherwise—and by night by ringing a bell and indicating upon a disc the words "Light out" whenever the lamp, by any accident, has been extinguished. This last point is effected by the expansion or contraction of a piece of metal within the lamp, according as the light is in or out, and which causes electrical contact to be made or broken, and the condition of the signal to be thus indicated in the signal-box. It will therefore be seen that all the conditions and requirements which it is essential for a perfect block system to possess are fully met and satisfied in the apparatus and arrangements which have been described.

The block system as a whole, when worked upon the most perfect principles, requires the employment of three wires; and when so worked, nearly every accident to which telegraphs are liable is eliminated. Motives of economy, however, have necessitated the introduction of block instruments which are worked by one wire. Opportunities are thus given for the entrance of the disturbing influences of atmospheric electricity, earth currents, and of those "moving accidents by flood and field" to which telegraphs are usually liable. The security of the block system is thus considerably weakened, but by a recent ingenious improvement, effected by Mr. Preece, even these causes of possible failure have been removed. This is effected by making the lowering of the signal, which is the emblem of safety, the result of the consentaneous action of the two men at the different ends of the section, so that no accidental current of electricity due to lightning, earth currents, or contact can produce a false signal. The apparatus by which this is effected is one of the most beautiful as well as recent combinations of mechanical and electrical science, and is now being adopted on all the branch lines of the South-Western system.

It has been asserted that the introduction of any form of the block system at once increases that element of danger—human fallibility—to a very great extent. It is undoubtedly true that accidents have happened under the block system owing to forgetfulness or error on the part of the signalman. But these have invariably happened with imperfect apparatus worked under imperfect regulations and supervision. The whole tendency of the block system is to reduce the element of human fallibility to a *minimum*, and whatever probability there may be of an accident from this cause under the block system, the probability of such an accident is very much greater without that system. It has been shown how a line is prepared for the approach of a train, how it is, as it were, closed behind the train, how these operations are governed and regulated by mechanical and automatic arrangements placed beyond the control of the signalman, and how, if any error is made by him, it is more likely to conduce to safety, and at the worst the delay of the train, than to accident. It is also urged against the block system that it removes the responsibility from the driver to the signalman, and that it tends to impair the careful look-out of the driver. The best answer to this is that those railway managers who have most extensively employed the block system disagree *in toto* with this opinion, and those who have used it longest are most decided in its praise. Captain Tyler, also, has stated that he does not find that the argument is justified by fact. It has also been argued that the introduction of the block system has a tendency to delay the traffic of a railway. Experience, however, has shown that the reverse is the fact when the length of the section is properly regulated according to the amount of traffic.

It cannot be too strongly impressed upon those interested in promoting the interests of the travelling public that the block system, theoretically and practically, tends to increase the safety of railway transit. Any failures that may have happened under its working are unquestionably due to imperfections in the mode of carrying it out. Mr. Malcolm, in his recent report to the Board of Trade, has truly stated as follows:—

"With regard to the block system, the criticisms passed on that proceed not upon the ground of the liability of mechanical arrangements to fail, but upon the assumption that it produces a feeling of false security among the servants who are working under it. This assumption is very generally made, and, indeed, admitted to some extent by Captain Tyler in his report, yet it is doubtful whether accidents traceable to it have hitherto occurred, while the accidents attributable to the want of the system are very numerous. Engine-drivers are not more anxious than are any other class of persons to be burnt, scalded, or crushed to death; and I would submit that, if the use of this system is, in the language of Mr. Moore, 'liable to create a feeling of confidence in the men,' it would be difficult to discover a more forcible testimony in its favour than the feeling of security thus created."

A few days later, Mr. Alfred O. Walker, telegraph superintendent, Darlington, made the following correction:—

"My attention has been called to an article in the 'Times' of the 11th inst. Perhaps you will kindly permit me to correct a slight error it contains.

"It is made to appear that the South-Western is the only railway using electric semaphore instruments for working the block system.

"Nine years ago I was in charge of the telegraphs on the metropolitan district of the South-Eastern Railway, under my brother, Mr. C. V. Walker, whose name is mentioned in the article I am commenting upon. We were at that time signalling the whole of the traffic at and about Charing Cross and London Bridge by means of the electro-magnetic telegraph semaphores, the joint invention of my brother and myself. Since that time they have been universally adopted over the whole South-Eastern system. During the last eight years they have been extensively used upon this section (the old Stockton and Darlington Railway) of the North-Eastern. In fact, wherever the exceptionally heavy and slow traffic upon the line would admit of their introduction, they have been at once brought into use.

"I will only further remark that we most religiously eliminate anything like delicacy in the construction of apparatus for train-signalling purposes, and the only beauty we claim for our instruments lies in their complete simplicity and security. I have some at work this day which have been signalling between three and four hundred trains daily, and have not been touched for some three or four years."

POTTERY Glaze.—SEGER gives the following analysis of Staffordshire glaze:—

Silica	40·56
Alumina	6·07
Oxide of lead	40·04
Ferric oxide	2·59
Oxide of manganese	7·14
Lime	2·58
Alkalies and loss	1·02
	100·00

This was probably formed from the following mixture:—

Quartz	28 parts
Litharge	40 „
Pipeclay	18 „
Manganese of first quality	9 „
Chalk	5 „
	100

To obtain a good homogeneous glaze it is not sufficient to mix the materals very intimately; they must be fritted together and then reduced to powder. *Dingler's Polytech. Journal, ccviii.* 234.

ASCHENBRENNER'S IMPROVED SUGAR-MAKING PROCESS.[1]

THERE is no process of chemical industry in which the waste reaches greater proportions than in that of sugar manufacture. Dr. Scoffern estimates the loss as nearer two-thirds than one-half, while another authority emphatically characterizes the proportion as enormous. The weight of the contents of a hogshead of sugar—according to an article on this subject recently published in "Iron"—is about 2,128 lbs. To obtain this quantity of sugar, 2,500 gallons of cane juice are often used, of a strength say of 9° Baumé. Each gallon at this average density contains 1·81 lbs. of sugar; hence 2,500 gallons contain 4,525 lbs. But the planter, as above noted, gets but 2,128 lbs.; hence the amount lost, or 2,397 lbs. is actually more than the maker has to sell. Of this loss 426 lbs. is molasses drained off, while the balance is waste of saccharine matter lost by caramelization; while ordinary processes have the still further defect of evolving, by the boiling of the cane juice, gases which impair the quality of the sugar.

With a view of overcoming these obstacles, the invention we herewith illustrate has been devised. According to the claims of its originator, the largest possible quantity of dry, pure, and naturally white sugar in marketable shape is produced. The importance of such an apparatus, if thoroughly efficient, cannot be over-estimated, not only as influencing a vast industry, but as directly affecting every consumer of the staple; and hence no further introduction will be needed to bespeak for the following description the careful consideration which its subject deserves.

The course of the juice, as it emerges from the grinding mill, is through the trough A, in which, at B, are arranged two inclined filters of different degrees of fineness, the liquid of course passing through the coarse one first. These filters are placed in two sets of grooves, so that one pair can be removed for cleaning, leaving a second couple continuing to act, so that the operation need not be interrupted. The object of these appliances is to stop the passage of mechanical impurities floating in the juice. The conduit B, discharges into a flannel, bucket-shaped receptacle C, which is also so arranged over a tank D, as to be readily removed for cleaning, and another quickly substituted, which serves to finish the initial filtering process.

The liquid is next conducted to three open kettles in succession. Each kettle has a double bottom, so as to be heated by steam. In these receptacles, the juice is precipitated by means of lime and magnesia, a process facilitated by the high temperature imparted by the steam, after which the sediment is drawn off by suitable tubes at the bottom. Thus purified, the liquid passes away through the siphons E to another filter F, which removes the last vestige of foreign substance which may still remain held in suspension. This apparatus consists of a metal case, in which is placed a second case, having two perforated ends and two perforated partitions, forming three compartments. The first is filled with sponge, the second with bone black, and the third with charcoal. At each end is an empty space for the entering and emerging juice. The inner case is provided with handles to admit of its being lifted out of place for cleaning.

The pump G then lifts the juice into the sulphur box H. This latter portion of the apparatus is of wood, encloses a paddle-wheel which is actuated by the steam-engine of the mill, and is fed with sulphurous fumes from the adjoining sulphur furnace I. The revolving paddles throw the fluid into rapid agitation, so that it is thus more thoroughly exposed to the action of the gas and caused, it is claimed, to leave the box in a perfectly bleached condition. The emerging stream, which is of about two-thirds of an inch in diameter, passes at once upon a long trough of sheet metal J, which, heated interiorly and underneath by steam, supplied through the pipes shown, serves to raise the temperature of the liquid to a degree not exceeding 194° Fah., by a condensation of 32° or 33° Baumé. Beneath this trough, at K, is arranged suitable apparatus for altering its degree of inclination at pleasure, thus hastening or retarding the flow.

Passing next through a connecting canal, the juice, in a stream half an inch in diameter, exits upon a second trough or box L. This conduit is arranged similarly to the trough J, and the liquid is here heated up to from 212° to 220° Fah., and thereby condensed to 40° or 45° Baumé. When it reaches the lower end of the incline, occupying from ten to twelve minutes in the transit, the stream has a thickness of one-third of an inch. At this point, in order to carry off all the vapour, hasten condensation, and prevent the boiling of the juice, a steam fan M is introduced. By the effect of this appliance, together with that of the processes to which it has already been subjected, the liquid becomes so thick as to necessitate the use of a scraping apparatus N, which consists of an endless band, passing over pulleys and provided with transverse blades placed at suitable distances apart. This is set in motion by the engine and serves to convey the material to another inclined plane similar to those already described, where it is acted upon by a second fan O. Finally the sugar, now in a crystallized condition, is removed by hand into the last receiver.

When it is desired to produce molasses, a small percentage may be obtained by making the incline of the troughs steeper, thus hastening the process and preventing the perfect drying of the sugar by the action of the two ventilators. The molasses thus made is said to be of the best quality and of the finest colour. The entire period of time occupied by the juice in passing through the apparatus is stated to be in the neighbourhood of forty-five minutes.

As regards economy, we are assured that the percentage of fuel saved is remarkably large—a fact which may be justly inferred from the advantageous and ingenious arrangement of heating surfaces, &c.

[1] From the "Scientific American."

ON ARTIFICIAL FUEL.[1]

By E. F. Loiseau.

IT is so evident that great advantages would be gained by coal operators, and by the public generally, from the utilization of what is known as *coal dust*, *slack*, *waste* or *culm*, that it is to be wondered that manufactories to transform this worthless material into a marketable fuel are not erected everywhere in the mining regions. The immense accumulations of coal-waste to be found in those regions are really a nuisance to the inhabitants and an eye-sore to the travelling public.

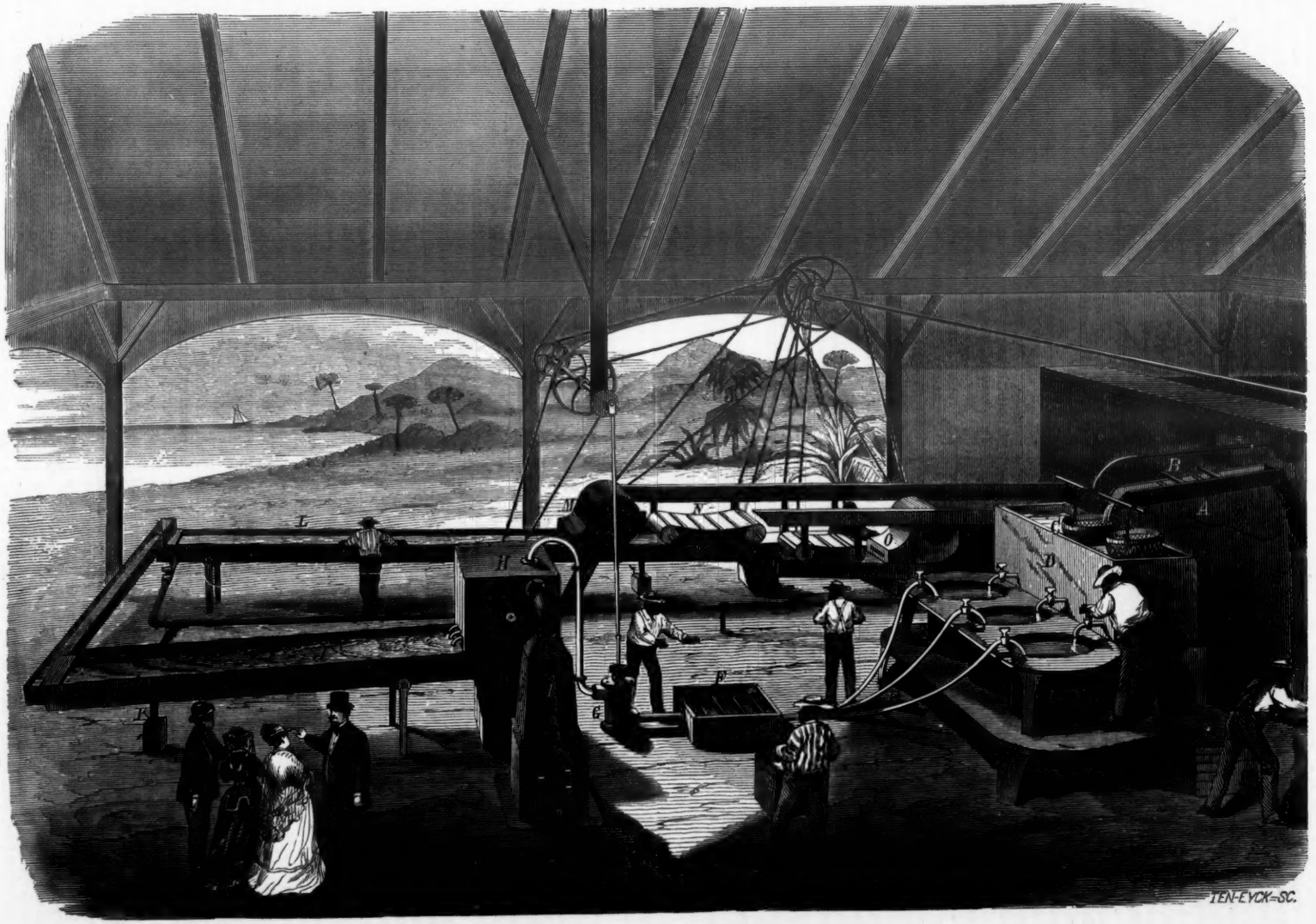
It is generally admitted that, on an average, from 40 to 50 per cent. of the entire coal production, both in this country and in Europe, is converted into dust or waste, the amount of which will be in proportion to the brittleness of the mineral and to the different operations to which it is submitted, in order to classify it by sizes for the market.

The utilization of this waste has been a problem which scientific and practical minds have tried to solve for a number of years. Partial results have been obtained by which a certain amount of the waste of coal mines has been utilized, and this only in Europe, where a gradual and constant increase in the cost of the natural coal has given to the manufacturers of artificial fuel a fair chance of profit; but it must be admitted that, compared with other branches of industry, the progress made in the utilization of coal waste has been very slow. The enormous increase in the cost of coal in England, France, Germany, and Belgium during the last three years has, however, brought again before the public, and this time prominently, the question of utilizing the waste created everywhere that coal is handled. The question, then, at the present day, which concerns the manufacture of artificial fuel, as we call it, or of patent fuel or agglomerated coal, as it is called in Europe, is not one of prejudice, but of necessity, for the waste of the coal resources, both in this country and abroad, has at last assumed such gigantic proportions, that some efficient means must be found for the economical utilization of the small coal which is now unavoidably made, even under the very best known systems of working coal.

Bituminous coal dust will coke well, and it is much used for that purpose, but the demand for coke not being in any way equal to the supply of bituminous small coal from which it might be made, a great proportion of the latter is left underground, and ultimately becomes lost beyond all possibility of future recovery. A small proportion of bituminous slack is used by blacksmiths and even on peculiar grates for engineering purposes, but the largest part is, as said before, left underground, or thrown into rivers, or piled up around the mines, occupying ground which

[1] A paper read before the Franklin Institute, January 21, 1874.

MUX



ASCHENBRENNER'S IMPROVED SUGAR-MAKING PROCESS.

might be better and more conveniently used for other purposes.

The waste created in the preparation of anthracite coal for the market is considered entirely worthless. It may be estimated that from 25 to 30 per cent. of the entire production of this coal is reduced to dust by the operation of the breaker alone. The vast, unsightly mounds of coal dust in the anthracite coal regions have become a familiar feature of Pennsylvania's landscape; they are increasing in number and in size every day, and it is estimated that the quantity of said waste exceeds to-day 30,000,000 tons.

Although several establishments have been created in France, England, and Belgium for the purpose of converting the coal waste into marketable fuel, that branch of industry is at present quite in its infancy. France has to-day twenty-eight, and Belgium nine manufactories of artificial fuel. In England the principal seat of those manufactories is in South Wales, whence steam coal is shipped chiefly for foreign ports.

Coal dust can be manufactured into solid lumps in two different ways: by simple compression without the addition of any cementing material, or by agglomeration with cements.

In England Messrs. Bessemer, Rees, and Buckwell, and in France Messrs. Baroulier, Evrard, and Loup, have patented different processes for the compression of bituminous coal dust into solid lumps without cements. The coal manufactured had a great heating power, but it could not bear handling and transportation.

Bessemer, heating previously the bituminous slack until it was brought to a plastic state, forced it, by a piston, into a long tube whose diameter was gradually reduced and from which the compressed coal was forced in a continuous cylindrical shape. By means of a revolving knife, the fuel was cut in sections of any required length, as fast as it was forced out of the tube. This process required very powerful machinery. Bessemer was compelled to reduce gradually the length of the tube and to increase its thickness, as it burst very often. The process required a large amount of natural coal to heat the dust to a pasty mass, and while being heated, it eliminated from the coal the greatest part of its volatile constituents. The application of Bessemer's process has long ago been abandoned.

Buckwell and Evrard compressed the bituminous waste into moulds without heating it previously. Although a powerful pressure was applied to the fuel the product would not bear handling.

Baroulier used circular iron moulds of a certain depth, open on top and at the bottom. These moulds were filled with coal-dust, and this dust compressed by hydraulic pressure: more coal was then added, this again compressed, and so on, until the moulds were completely filled. The moulds were then placed, side by side, on an iron plate, in a car having perforated sides and bottoms; another plate was then placed over all the moulds and bolted to the one on which they rested; another series of moulds were placed side by side, on that second plate, covered by a third plate, securely bolted to the second one, and so on until the car was filled. This car was then taken to an oven heated to 400° Fahrenheit. The plates between the moulds prevented the expansion of the coal and the escape of the volatile matters contained in it. This process, although a real improvement on Bessemer's process, had some of its defects; it required much labour, a large quantity of moulds, plates, iron cars, &c., which had to be replaced very often, and it also consumed a large amount of coal. The expenses were so excessive that the manufactured fuel could not be sold in competition with the natural coal. The establishment erected by Mr. Baroulier at Gangreneuve, near St. Etienne, France, was in operation only two years, 1857 and 1858.

These are the only serious attempts which have been made to convert bituminous coal-dust into solid fuel without cement. Rees took out an English patent for a process similar to Baroulier's. He did not meet with more success than my countryman did.

Among the numerous cements which have been patented for the manufacture of artificial fuel are to be found the strangest substances, such as spoiled flour, blood, gum arabic, animal and vegetable oils, cow dung, rakings of roads, sweepings of houses, common salt, sal ammoniac, sulphur, solutions of glue, alkaline silicates, alum, copperas, &c. &c. It is unnecessary to add that of these singular materials none have ever been brought into practical use.

Among the cements which have been used to a certain extent may be cited rosin, asphalte, petroleum, coal-tar and its derivative fluid, and dry pitch, lime, plaster, starch and clay.

Professor A. S. Bickmore, in a very interesting paper on "Coal in China," read before the American Association, says that "from time immemorial, in the north of China, coal is ground to dust and mixed with clay, that it may burn more slowly."

In 1603, a pamphlet entitled "A new, cheap and delicate fire of coal balls" was published in London by Sir Hugh Platt. This gentleman recommended for use in common fireplaces a mixture of coal and clay, moulded by hand in the shape of balls. He also used another mixture which consisted of coal-dust, tanner's bark, sawdust and cow-dung. The preparation of the materials with water and the moulding of the composition into balls, by hand, is fully described in that pamphlet.

Another pamphlet, also published in London, 1679, and entitled "An excellent invention to make a fire," contains the following recipe: "Take three parts of the best Newcastle coal, beaten small, one part of clay; mix these well together into a mass with water; make thereof balls, which you must dry very well. This fuel is durable, sweet, not offensive by reason of the smoke or cinder as other coal fires are, beautiful in shape, and not so costly as other fire, burns as well in a room even as charcoal."

In an article on the coal basin of Eschweiler, Mr. Clère, a French engineer of great reputation, states that "at Liége, (Belgium,) coal-dust is mixed with clay, pressed by hand in the form of balls, dried in the sun and stored away for domestic use. That kind of fuel is there called Hochets." I can add to this, that even to this very day not only at Liége, but everywhere in Belgium, coal-dust is used in the same manner.

There exists in Belgium a certain class of working women who earn a scanty living by converting the coal-dust into solid fuel. They call at every house in front of which a load of coal-dust has been dumped, offering their services. These poor creatures can be seen daily in the streets, always two or three together, each one of them pushing a wheelbarrow loaded with clay, in which stands a shovel. They try their best, if the house is occupied by people in easy circumstances, to obtain a little more than the price which is usually paid to them. As soon as the price is agreed upon, they go at work in earnest; the coal-dust is shovelled all around so as to form a circular bed of about one foot in thickness. From 25 to 30 per cent. of clay is diluted with water and sprinkled over the coal, which is well mixed with the clay by means of the shovels first. Then, putting on wooden shoes and slightly lifting their skirts, they commence to trample upon the coal, turning round the coal bed from the circumference to the centre, and back again from the centre to the circumference, following each other like ducks. When the whole surface of the coal bed has been trampled upon twice, the mixture is turned over with the shovel, and the trampling recommences. After five or six operations of the kind have been gone through, the coal and clay have been worked to a plastic mass. This is piled up in a heap, and, seating themselves on their wheelbarrows, these poor women proceed to compress the fuel in the shape of balls, by hand. These balls are then dried in the sun, after which they are ready for use.

This very primitive and original way of mixing and compressing coal dust into lumps has never been patented.

In some parts of Germany the trampling on the coal is done by men on horseback. In the Rhine regions the mixing of clay with coal is an affair of constant occurrence. Many a traveller has opened his eyes on seeing a bushel or two of clay dumped with every cart-load of coal, and carefully mixed in with it by the attendant coal-heaver. But he is still more surprised to see his servant gravely empty a pail of water into his coal-box, together with the morning's supply of fuel. The coal is mostly slack, and the fires do not burn well if the coal is dry.

At Ham-sur-Sambre (Belgium), in 1859, under the direction of Mr. Darbois, machines, invented by Mr. David, a French engineer of merit, were erected for the purpose of manufacturing, by mechanical pressure, solid lumps from semi-anthracite coal dust, mixed with 15 per cent. of clay. With these machines lumps of cylindrical shape were pressed, also cylindrical lumps with perforations half an inch in diameter, through the centre. These machines were very expensive, and their production was very limited. In 1861 they were replaced by cheaper and more productive machines, invented by Mr. Martin, from Liége (Belgium). These machines, making egg-shaped lumps, met with more favour, as the product was very similar to the lumps pressed by hand. Martin's press is still in operation at Ham-sur-sambre.

At Tamines-sur-Sambre (Belgium), in 1862, under the direction of Mr. Cavenaile, the company of the "Charbonnages Réunis de la Basse Sambre" (United Colleries of the Lower Sambre), of which I was at that time the general agent, erected also Martin's machines to convert the coal dust into egg-shaped lumps, by using 18 per cent. of clay as cement. Martin's press made only one lump at a time; its length was 6 in., and its diameter in the centre 4 in. The feeding was very defective. This little model gives you an idea of Martin's press. Two rollers, having on their periphery one-half of an egg-shaped mould, revolve in opposite directions. In a hopper, placed above the rollers, is

thrown the coal dust and clay, previously worked into a plastic mass. It was expected at first, that the mixture, by its own weight, would fall between the rollers; but it did not, and two men had to be employed to force the mixture between the rollers. These men, by means of pounders, would alternately pound the materials through the hopper, while a third one was shovelling the plastic composition into it. As this work was very fatiguing, the men had to rest every half hour, and were replaced by another set of men, who worked also half an hour and rested, while the first men resumed work, and so on. The last improvement in the feeding part was to place, in the centre of the hopper, a vertical screw to force the mixture down. It seems that in 1867 some more improvements were added and patented by Simon Baudry, from Tamines (Belgium), both to the compressing and to the drying apparatus. In Martin's process, the lumps of fuel would be delivered from the rollers on a short endless belt, from which they fell into very open-worked baskets. When filled, these baskets were carried away by boys and placed on shelves, under a shed, where the coal dried by simple exposure to the air. The roof of the shed was composed of sections of waterproof canvas, which were rolled up during fair weather. This slow and very imperfect method of drying economized fuel, but required a large number of boys.

Baudry invented a drying oven, with shelves all round; the fuel coming from the press would fall on perforated sheet iron trays instead of falling into baskets, and these trays were placed on the shelves in the oven. It required two hours to dry the fuel. The oven was then opened at both ends, and as fast as the trays containing dry fuel were removed from it they were replaced by others containing freshly moulded fuel, which had been temporarily piled up near the oven. During this operation, the doors being open, the interior of the oven cooled down gradually, the work of removing its contents and of filling it anew had to be done very rapidly, and required also a large number of boys. Labour being relatively cheap in Belgium and coal selling high, no improvements have been made to suppress unnecessary handling. Notwithstanding the defects of Baudry's process, it is still applied in Belgium, the product containing 18 per cent. of clay and not being impervious to moisture. The large percentage of clay and the fuel not being able to stand exposure to the weather are the greatest obstacles to the development of the manufacture of artificial fuel by the use of clay as a cement. Mr. Henry Gerondeau from Liége (Belgium), in an article on the agglomeration of coal dust, published in 1861, says that "if the proportion of clay could be reduced to a small percentage, and the product be made impervious to moisture, clay, which is the best and the cheapest, would undoubtedly supersede all other cements."

As I have said before, asphalt, rosin and petroleum have also been used as cements, but these materials have been found wanting in cohesive property, and also too expensive. Coal tar and its derivatives, fluid pitch and dry pitch, have been the most extensively used.

The idea of mixing coal dust with coal tar originated with Peter Davey, an Englishman, who, in 1821, took out an English patent for what he describes as "consisting in an improved preparation for coal for fuel, which I call gaseous coke, and which is made of very small coals, mixed with coal tar (either in a pure state, which is best, or combined with naphtha and those other ingredients with which it is generally found impregnated), and then cemented together by the application of heat, in the form of large lumps or cakes, for the purpose of fuel." The mixture is pressed into moulds, which are placed for four hours in an air furnace heated to 350° Fah.

This same Peter Davey had obtained, twenty-one years before, in 1800, an English patent for an improved fuel, which he describes thus:—"Small coals are mixed with charcoal or wood, breeze, turf, tan, saw-dust, cork-cuttings, peat, or other inflammable ingredient or ingredients. These materials are then well mixed and put into kilns, ovens or other furnaces, either dry or moistened, and, by means of dampers, slides, vent or air holes, or other contrivances, the heat is so regulated as to be equal to cementing the materials without destroying them."

This was rather a singular mixture of ingredients, but Peter Davey persevered in his researches, and during the twenty-one years which elapsed between the dates of his two patents, no one knows what dreadful mixtures that man must have tried.

During those twenty-one years no patents were applied for in England, and two only were issued in France—one to a Mr. Quest, June 18th, 1810, for a mixture of coal dust and clay, and another to a Mr. Burette, June 12th, 1811, for compressing bituminous coal dust without cement. Peter Davey, then, may be considered the father of the artificial fuel industry.

From 1821 to this day a considerable number of patents have been issued, both in America and abroad, either for so-called new processes or for the machines to apply them.

Coal tar was first used in France by Ferrand and Marsais. Their first experiments commenced in 1832, but, after a great many unsuccessful attempts, Mr. Ferrand having died, Mr. Marsais abandoned coal tar and tried fluid pitch. This was a successful stroke. He erected, in 1842, a factory at Bérard, near St. Etienne, which was in operation during three years. He then removed his establishment to Gisors, where the coal company of St. Etienne is still manufacturing artificial fuel by Mr. Marsais' process, and that in the same factory erected by him twenty-eight years ago.

Among the inventors who have really improved the means of manufacturing artificial fuel, by using either coal tar, fluid pitch or dry pitch, the names of Grant, Rathwell, Cooke, Wylam, Warlich, Dobrée, Moreau and De Haynin are prominent.

Fluid and dry pitch formed a good cement for bituminous and semi-bituminous coal dust, but it did not succeed as well with anthracite and semi-anthracite waste, which is mined in South Wales and in some parts of France and Belgium. Before the cement is consumed the bituminous artificial fuel is coked, and consequently it does not crumble in the fire. It is not the same with anthracite or lean coal dust. When cemented with coal tar or pitch, or any other resinous material, the cement consumes in the fire more rapidly than the coal, and the particles of coal, having lost their adhesive coating, crumble in the fire and fall through the grates without being consumed.

Resinous materials expand when burning, while clay, on the contrary, contracts progressively when submitted to elevated temperatures. Clay, used alone, would not have given a fuel impervious to moisture. It was supposed that, by mixing clay and pitch with the coal dust, the fuel manufactured would not only be waterproof, but would remain in the fire, without crumbling, until consumed, the shrinkage of the clay compensating for the swelling of the pitch.

Among the experimenters in that direction we have men who have really improved the manufacture of artificial fuel. The most eminent of those inventors are Chabannes, Sunderland, Stafford, Oram, Geary, Goodwin, Mohum, Sterling, Albert, Newton, Holcombe, and one of the great Smith family.

All these attempts were unsuccessful. The presence of pitch in the fuel made it unfit for domestic use, and the clay impaired its combustible character for manufacturing purposes.

Patents were also granted to several inventors for a mixture of bituminous and of anthracite coal-dust and coking the mixture. The first one of these patents was granted, in 1823, to John Christie and Thomas Harper in England.

The result was the same as with Bessemer, Baroulier, and others. The machinery was too expensive, and the product was not marketable. The coke had no density, it was very porous, owing to the fact that the particles of anthracite would not unite with the bituminous, and remained in a loose state in the cells of the coke. It burned well enough, but it was rapidly consumed, and would not bear handling.

In 1838, April 26th, a patent was granted in England to Thomas Joyce, of Camberwell, for "certain improved modes of applying prepared fuel for the purpose of generating steam and evaporating fluids, the fuel to be used in chambers or furnaces, to be wood, coke, coal, charcoal, or other fuel, prepared, chopped or broken into small pieces, so as to insure its falling down the fuel chamber as the lower part of the fuel is consumed. It may be saturated with an alkali solution."

The combustion chamber consists "of a vertical cylinder, with a grate and apertures to support combustion at the bottom; it is filled with fuel, which only burns at the lower part, the upper part falling down as that below burns away; the flame and smoke pass out through side passages surrounded by the water in the boiler."

This same inventor, on the 12th of November, 1838, obtained also a patent in this country.

The United States patent seems to have been confined to the fuel as used in a stove for heating rooms, &c. The invention made much noise at the time, and was considered a real improvement by many persons eminent in chemical science, but the plan was long since abandoned, and considered as an utter failure. The proposed fuel in this patent consisted of charcoal heated with potash, and the stove was to be without a pipe, the products of combustion all escaping into the room. The carbonic acid was to combine with the potash, and thus to prevent all injurious effects from it.

The English patent of Thomas Joyce contained evidently the germ of the self-feeding anthracite stoves in general use to-day.

In 1845, Richard Archibald Brooman obtained an English patent for "mixing coal waste with india-rubber and gutta-percha combined, or each of these alone." This was quite an elastic cement.

The most singular patent ever issued was granted, in 1840, to Thomas Kerr, of England, for a new composition for artificial

fuel and other purposes. This composition is formed, first of the "rakings of roads, or streets, or other public ways, or the sweepings of houses, offices, and other buildings, or of the ashes of coal or other fires, or of small coal, culm, breeze, or of river or sea sand, or of freestone, or other stones pounded into dust, or of any other mineral or vegetable substance in a state of dust or powder.

"Secondly, of chalk or any other similar calcareous substance of a drying and retaining nature, ground into a fine powder.

"Thirdly, of tar, or pitch, or oil, or rosin, or some other substance of the like bituminous, fatty, or inflammable nature, such as the common Archangel tar, in the same state as imported, coal tar as it comes from the gasworks, the pitch that is manufactured from coal after the naphtha has been extracted, whale oil, linseed oil, and other oils, and,

"Fourthly, simple clay or common salt. These ingredients described under these four heads are combined in a variety of proportions and used for fuel, and * * * for an infinity of other purposes."

Now, what can those other purposes have been?

Some Americans, or naturalized Americans, seem to have been as erratic as this Englishman was. I find three patents granted in 1865 for the following compounds:—

To Henry Redlich, June 27th.

Coal dust	4 parts.
Cow dung	3 „
Blood	1 „

To Chas. Korff, July 4th, one week after Henry Redlich.

One ton	Coal dust.
One gallon	Blood.
One gallon	Water.

Such a patent granted on the anniversary of American independence! This Korff had evidently contracted his disease from Redlich.

To Samuel D. Hovey, October 24th.

100 parts	Coal dust.
1 „	Glue.

Some inventors, thinking that coal does not contain sulphur enough, and probably supposing that it improves the fuel, especially for metallurgical purposes, add to their mixture, as described in their specifications, large quantities of sulphur, some of them as much as three per cent.

A large number of patents have been granted in this country for artificial fuel. Most of them are modified copies of foreign patents, and a good number denote in their description a complete ignorance of the calorific properties of fuel and of the laws of combustion. The only one which, in my opinion, possesses real merit has been lately granted to Doctor Joshua R. Hayes, of Winchester, Pa. This patent was issued on March the 4th, 1873.

Mr. Hayes uses coal dust, clay and asphaltum; but although the manner in which he combines these materials is new and ingenious, the product will be liable to the same objections made against the fuel manufactured in Europe from coal dust, clay and pitch, by Stafford, Oram, Goodwin, Geary, and others.

The manufacture of artificial fuel, although being far from having attained the importance which it must attain in the near future, has been developed more rapidly in France and in Belgium than in England. English coal is harder than French and Belgian coal, and until within the last three years, the price of coal in England was so low that there was no inducement for capitalists to invest their money for the development of an industry which presented but poor prospects of good dividends. But increase after increase in the price of coal, during the last three years, has entirely changed the state of affairs. Large companies have been organized last year, with immense capital, for the manufacture of "patent fuel" by different processes. The last one patented in England, and which has also been patented in America, is the invention of Martin Rae, of Uphall, North Britain.

It consists in mixing with coal dust 15 per cent. of what he calls a bituminous *mastic*. This mastic is prepared in the following manner:—Crude shale tar obtained in the distillation and refining of mineral oil of bituminous shale, is freed from sulphuric acid by means of steaming and washing in lime water. It is then run into a still, where the water and a portion of the oils is distilled off, which process renders the shale tar more dense and tenacious, being in a state between tar and pitch (which is exactly the state of what is called fluid pitch). A pipe from the bottom of the still conveys the mastic to a pan where the heat is kept up to about 200° Fahrenheit. From this pan the mixing machine, containing the coal dust mixed with about 5 per cent. of powdered clay, is supplied with the requisite proportion of mastic.

From the mixer the plastic mass is conveyed to a press, to be moulded, and from there to the drying oven. In this process we have again a mixture of clay, coal dust, and some other bituminous material, fluid shale pitch.

A company was organized in May, 1873, with a capital of 1,000,000 dollars under the name of the "Diamond Fuel Company," to apply David Barker's process.

In this process a peculiar mucilage is mixed with the coal dust in the proportion of two ounces of mucilage to one pound of coal dust. The mucilage is manufactured in the following manner: One part of farina from which the gluten has been removed and which consists entirely or almost entirely of fecula or starch, is mixed with twenty parts of water, and to this is added a solution of sulphate of alumina or of chloride of alumina in hydrochloric acid, in the proportion of one ounce per gallon. The mixture thus formed is conveyed into a tank heated by steam, in which it is boiled and then run off, through a tap, into a boiler in which are placed pitch and carbolic acid, in the proportion of eight parts of the former to two of the latter. The whole contents of the boiler are subjected to the operation of boiling under moderate pressure, by which treatment the several substances contained in the boiler are caused to unite. Steam is then turned on into the boiler, and the contents thereof forced through pipes into a tank, whence the liquid is conveyed to the mixer by means of elevators, cased with sheet iron and wood, between which steam is introduced to keep the liquid from solidifying. In the mixer the coal dust is conveyed by a separate set of elevators, and is thoroughly amalgamated with the above described compound. The mixture is then compressed into lumps and dried in an oven.

It will be observed that in these two processes, as well as in the old one of cementing coal dust with pitch, or rosin, or asphalt, a large amount of natural coal is consumed, not only to dry or carbonize the product, but also to heat the cement and the coal dust itself. If the dust was not heated, the cement would not adhere to the particles of coal. There is also the unnecessary handling in carrying the fuel to the drying oven, and removing it when dry.

Both Martin Rae and David Barker are inventors, not only of the process, but of the machinery for its application.

The mixing machines in Europe are almost all constructed on the same plan; they consist of vertical or horizontal cylinders, differing only in diameter, in height, or in length. In the centre revolves invariably an upright or horizontal shaft, to which are fastened, by set screws, a series of knives, blades, arms, or paddles, set at a certain angle to force the materials downward or forward. To prevent the cooling of the materials, all the mixers are either surrounded with steam jackets, or furnished with openings, to which are adapted steam pipes to convey steam into the mixer. Some of these mixers have steam passing through the shaft and even through the arms or paddles. No improvements, worth noticing, have been made in the mixing apparatus for the last forty years, while the compressing machines have been improved from year to year. This singular fact was noticed by Mr. L. Gruner, who, in a very elaborate article on artificial fuel, published in 1865, said that "it was to be regretted that the efforts of inventors had been almost exclusively directed towards improving the compressing machines." He had no doubt that if the mixing of the materials was more complete, if they should remain longer in the mixer, the proportion of cement, no matter what that cement should be, could be reduced considerably, which would, as a natural consequence, reduce the cost of fuel. To attain this very desirable object he suggested an increase in the diameter of the mixer. The suggestion was a good one, still no improvements were made. I have seen at Bouffioulx, Belgium, a vertical mixer, about 20 ft. high; it was calculated that with such a mixer, the materials would remain in the apparatus about half an hour, instead of ten minutes, and sometimes less, as they did before. The pressure of the column of coal dust was so great that, when the power was applied, all the arms broke off one after another, except the six upper ones. This mixer was then replaced by an horizontal cylinder 40 ft. in length. It worked better than the former; but the mixture not being plastic enough, two horizontal mixers were placed above one another. The materials falling into the hopper of the first one, would travel the entire length of said mixer and be discharged into the hopper of the lower one, at the end of which the materials would come out in a perfect plastic state and ready for compression. At Montigny-sur-Sambre, Belgium, Mr. De Haynin used a horizontal mixer about 65 ft. (20 metres) in length, heated all around; it may be imagined what trouble it must have been to keep such an apparatus in good working order.

Although the compressing machines used in Europe are nume-

rous, they are all modifications of four distinct mechanical modes of applying pressure. First, by means of rollers; second, by pistons in closed moulds; third, by pistons in open moulds; and fourth, by pistons pressing cylindrical lumps with a hole through the centre.

Under the first class we have the following machines.

An endless chain, carrying moulds, working horizontally on a long table, passes under a hopper, from which sufficient material in a loose state is supplied to the moulds, to obtain lumps of a given density when compressed. These moulds pass under a roller, which revolves in an opposite direction, and forces the loose materials into the moulds. The lumps are then discharged from the moulds by a piston. This machine was also invented by Bessemer, and has been in operation in England and in France to make bricks.

Another machine has two rollers, revolving in opposite directions, one of which has on its face square cavities with movable bottoms, the face of the other roller being smooth. The plastic mass, fed between the rollers from a hopper above, is forced by the smooth roller into the cavities of the other one. At the lowest point of the course of this last roller, the movable bottoms are pushed forward by an eccentric, and the lumps, being relieved, fall on an endless belt, from which they are taken by hand and piled up in cars to be dried. This is more a moulding than a compressing machine. It was the invention of a German named Milch, and has been in use at Halle, Germany, to press lignite.

A third machine, invented by Mr. David, of Havre, has also two rollers, one of which has, like the preceding one, square cavities with movable bottoms, while the other one has projections which exactly fit those cavities. The plastic mass is forced into them by those projections, and at the same time, by an ingenious device, the bottom of each mould is alternately pushed forward a certain distance, so that the materials are pressed on both sides. An eccentric, as in Milch's machine, pushes the bottoms of the moulds far enough to relieve the lumps, which fall also on an endless belt. The removal of these lumps, and their drying, is done by boys, who receive them in baskets as they fall from the endless belt. This machine is in operation at Montchanin, Brest, Caen, and Havre.

A fourth machine, the invention of Mr. Jarlot, of Lorient, France, has two very peculiar rollers. Their thickness is about 3 in. To one side of each is bolted a cast-iron cylindrical ring 8 in. in thickness and 8 in. face. Through that thickness are bored, at certain distances, cylindrical holes, of larger diameter on the face, and gradually reduced about one-tenth at the other end. The rollers are so placed that, when they revolve in opposite directions, the solid space between the openings of one roller exactly meet the openings of the other. A certain quantity of plastic mass is thus forced alternately in the openings of each ring, and the fresh materials forced in push forward towards the end of the opening the coal which it contained already. Pressure in this machine is produced by friction of the materials along the sides of the openings. At each revolution of the rollers some more material is forced in, and the pressed fuel gradually emerges inside the ring, in a continuous cylindrical shape. When it is projecting a certain length, a stationary knife, which can be adjusted, cuts it off, and the lump falls along an inclined plane into wire baskets, to be carried to the drying oven. This machine is in operation at Languin and at Bordeaux, France.

There has also been in use, during a few months, with very poor results, a machine invented by Mr. Verpilleux, of Rive de Gier, France. He used two smooth rollers, one of which was adjustable, so as to separate it from any other at any desired point. The plastic mass passed between these rollers as a thick band, and was cut into sections by a revolving knife placed underneath. This was simply laminating but not compressing.

I have described Martin's and Baudry's machines at length. As you will remember, they use two rollers having on their peripheries one half of an ovoid or egg-shaped mould. It is on the principle of these machines that my press is constructed.

The following are among the inventors whose machines, compressing by a piston in a closed mould, belong to the second class, viz.: Marsais, Poplin-Ducarre, Moreau and David, Middleton, Mazeline and Couillard, and Revollier.

Marsais compresses the coal, by hydraulic pressure, into large and very heavy square moulds. These moulds have lids and also movable bottoms. When filled with the materials the lids are bolted to the moulds, and these are carried under an hydraulic press. The movable bottom is pushed upward and compresses the contents of the mould against the lid. A safety valve opens when the pressure exceeds certain limits. The lid is then removed, and the mould is carried under another press, which pushes the movable bottom upward with the lump on it. This lump is placed on a car and carried to the drying oven. It requires ten minutes to mould one lump, which weighs about 465 kilograms or very near 1,000 lbs. After being dried it is broken to pieces with hammers. In breaking it a large amount of the fuel is again reduced to dust.

Poplin-Ducarre's press, like that of Moreau and David and others, is composed of a series of pistons, placed vertically or horizontally, pressing the coal into a series of moulds placed in the same way. When the pressure is applied by vertical pistons, there are two series of these working alternately; one to press the coal and the other to push the lumps out of the moulds. The frame containing the moulds is movable, and is placed on a stationary perforated table. When the coal is pressed and the compressing pistons have left the moulds, the frame which holds these moves sideways, so as to bring the bottom opening of the moulds exactly over the perforations of the stationary table. The lumps are then forced out of the moulds through those perforations by the other pistons. The moulding frame returns to its place, and the same operation recommences.

This machine is only used for the manufacture of what is known as "charbon de Paris." The materials are charcoal dust, saw dust and coal tar. The lumps are cylindrical.

When the pistons are placed horizontally, the moulds remain stationary and the materials are pressed against strong movable gates. In this case we have a double set of moulds and pistons, and the same pistons both compress and discharge the lumps. The mixture, which fills the moulds from hoppers or from chutes communicating with the mixing machine, is first pressed against the gate of one side, which moves up and down in front of the moulds, and by a further pressure the lumps are discharged, while the gate comes down. During this operation the gate on the opposite side comes up and the moulds are filling. The same operation is then repeated by the other set of pistons. Both sets are worked by a yoke and cams.

A serious defect of these presses is that the pressure is not gradual, but is given by a sudden blow. The feeding being very irregular, the lumps have not a regular density. Their production does not exceed 25 tons per day, the lumps weighing four pounds each.

Machines constructed on the same principle and which I have found, by personal experiments at Nesquehoning, to possess the same defects, have been patented in America by John B. Colleen and by T. M. Mitchell, both of Philadelphia.

The presses of Middleton, Revollier, and Mazeline and Couillard, have a solid circular turning table, containing a series of square moulds. While the table is revolving, the moulds pass in succession under a mixer or pug mill from which they are filled. In the centre of this mixer or pug mill is an upright shaft, to which are fastened, by set screws, and at any desired angle, a series of knives, which mix the materials and force them downward.

In Middleton's press this turning table is placed so as to rest upon a stationary one, having the same diameter. The stationary table serves as bottom to the moulds of the turning one and has only one large square opening, through which each lump is discharged. The motion imparted to the moulding table is intermittent. The moulds are successively brought under a pug mill to be filled, then under a piston, which compresses the materials against the stationary table, and finally under a second piston, which forces the lump out of the mould through the opening described before, so that, while one mould is being filled, a lump of artificial fuel is pressed and another one is discharged. This press, which was at first adopted in all the Belgian factories, has a great defect. The jerking motion of the turning table has to be regulated with the greatest precision, so that the compressing piston and the discharging one exactly meet the moulds. The slightest deviation would break the piston rods. Middleton's press has been replaced everywhere in France and in Belgium by Revollier's press for a large production, and by Mazeline and Couillard's press for a small one.

In Mazeline and Couillard's press the moulding table revolves continually. In each mould is a movable bottom, having a small roller under it. These bottoms travel on an inclined helicoidal plane. Whenever a filled mould passes under a strong cast-iron block, the bottom gradually comes up the inclined plane and compresses the materials against that block, and while the rotary motion keeps on, the lump is gradually brought to the surface of the moulding wheel. At this point a scraper, worked by an eccentric, pushes the lump on an endless belt, and springs back to push off again the next lump, and so on. The bottom of each mould gradually comes down, and leaves room for the plastic mass to fall into it from the mixer. The lumps weigh about 20 lbs.; as the moulding table contains 10 moulds, and makes 2½ revolutions every minute, the production is from 13 to 14 tons per hour.

These machines are in operation at Blanzy, Anzin, Valen-

ciennes and Havre, in France, also in England, Germany, Belgium, and even in two factories erected last year in Spain.

Mr. Revollier compresses by hydraulic pressure. The moulding table of this machine is about 10 ft. in diameter, and is divided into four sections, each one of which contains a certain number of moulds, according to the size desired; in each mould is an independent movable bottom. During each revolution the table stops four times. The moulds of one section are all filled at the same time; the table then makes one-fourth of a revolution and brings that section under a strong cast-iron block and over the pressing plate. This plate forces all the moveable bottoms upward, compressing the coal contained in the moulds against the block. Another fourth of a revolution brings that section over a second plate, which works upward in the same manner as the pressing plate, and forces all the lumps out of the moulds at one stroke; where the moulding table completes a revolution, the lumps are placed in front of a scraper, worked by an eccentric. This scraper comes forward and pushes all the lumps at once on an endless belt, from which they are taken by boys. Although this seems to be a very slow method of compressing coal-dust, the production exceeds that of Mazeline and Couillard's press, because each stroke of the piston makes 20, 30, and even 40 lumps, according to their size. The press is so constructed that the moulds can be changed at will, when larger or smaller lumps are required for the market. The production of this press varies from 20 to 25 tons per hour.

Bessemer's first machine, by which the coal-dust heated to a plastic mass was forced through a long tube, belongs to the third class of presses. As I have said before, the tube was reduced in length and increased in thickness, on account of its bursting very often.

Mr. Evrard improved Bessemer's process in this manner. Sixteen cylindrical moulds are placed horizontally on a turning table as the radius of a circle; each mould contains a piston and is open on the top sufficiently to receive the plastic mass from the mixer while it passes under it. The pistons are worked by means of a strong eccentric and 16 short links. The cylindrical end of the moulds is formed by two semi-cylindrical sections screwed together, so as to allow some space between them, if necessary. At each stroke of a piston a small lump is pushed out of the mould. The pressure is applied gradually, and as a consequence the lumps are solid and have no cracks.

These machines are in operation at La Chazotte, La Grande Combe, France, and have also been tried by Mr. Dehaynin at Montigny-sur-Sambre, Belgium, but their production being very limited Revollier's press was preferred.

M. Moreau, of Paris, manufactures cylindrical lumps by using a horizontal cylinder, slightly conical at the end. In this cylinder revolves a screw which pushes the materials, falling into the cylinder, from a hopper placed above it, towards the conical end, and forces the plastic mixture out through a small cylindrical opening. As fast as the pressed fuel emerges from the cylinder, it is cut into sections of any required length by a revolving knife. This is an imitation of a machine invented by M. Devinck, of Paris, for the manufacture of chocolate sticks.

The fourth class includes different apparatus, which are simply modifications of machines used in the manufacture of hollow bricks and of drain pipes. Mr. Dehaynin tried in his factory of Montigny-sur-Sambre a machine of that kind, patented by a M. Bourrier. The results were not favourable. M. Dehaynin has been the most persevering man in the artificial fuel industry. He has encouraged inventors in that line, tried their machines, and has furnished a great many with the means for experimenting. He is to-day the proprietor of four establishments, in which 1,500 tons of artificial fuel are manufactured daily for the railroads and for the French navy. He has acquired immense wealth, and he certainly deserves it.

Most of the machines which I have described have also been tried to convert peat into a dense fuel. Some of them have answered the purpose very well—Milch's machine, for instance. Large peat factories are in operation at Stalbach, Halle, Haspelmoor, and Neudstadt, in Germany, and at Montangin in France.

I have derived very valuable information on the subject of artificial fuel from Messrs. Gruner and Gerondeau's works, from Armengaud's publications, from several European scientific publications, and especially from the Philadelphia Journal of Industry, published in 1870 by Henry Howson, the well known patent attorney.

Having given you a summary description of the different processes and of the machinery used for their application, I will now proceed to describe what appears to be their deficiencies.

It is evident that no artificial fuel containing a resinous substance will ever be used for domestic purposes, on account of the smoke and of the bad odour. Another objection is that such a fuel is liable to spontaneous combustion. No objection of the kind can be raised against artificial fuel cemented with clay and milk of lime.

By mixing the coal-dust and the cement in a vessel, which contains only one single shaft with blades, the materials are turned around always in the same direction; and it takes a long time before they are brought to a plastic state. Increasing the length or the number of horizontal mixers requires too much valuable space, and is very expensive. A better result would certainly be obtained if the diameter of a vertical mixer was increased, and if several upright shafts commanding each other, and consequently revolving in opposite directions, were used instead of a single one. The knives of these shafts, crossing each other in all directions, would undoubtedly perform a quicker and better work than the blades of one single shaft. Practical experiments have demonstrated this fact.

T. M. Mitchell, of Philadelphia, the patentee of different machines erected at Nesquehoning, Carbon County, Philadelphia, used a vertical mixer with four shafts, which worked very well. It had, however, some defects. There was no possibility of ascertaining if the mixture had acquired a sufficient degree of plasticity; and when the mixer had to be cleaned, or some obstacle had to be removed from it, or some arm broke and had to be replaced, the whole machine had to be taken to pieces, which occasioned much trouble and a considerable loss of time. Still it was a decided improvement on all the European mixers. It is with that apparatus that I succeeded in reducing the proportion of clay to 5 per cent.

In my process I use the slack without heating it or drying it previously. The moisture which it contains varies with the state of the atmosphere; therefore, I am compelled to regulate the supply of lime-water accordingly. The difficulty of ascertaining the state of the materials inside the mixer suggested the idea of placing sliding doors around it. These doors facilitate the cleaning of the mixer, and the removal of stones or pieces of iron, which are found very often in the coal-dust. By means of a movable spider, which allows the removal of each shaft without interfering with the others, and without removing the stationary frame in which they stand, a broken arm or a worn-out one can be replaced by new ones in half-an-hour.

Although the compressing part of some only of the European presses is defective, the feeding part of almost all of them is very deficient. The materials to be pressed containing at certain times more moisture than at other times, the feeding of these materials to the press ought to be reduced or increased accordingly; and to effect that purpose, simple and efficient means are necessary.

The pressure should be applied gradually in order to expel, as much as possible, the moisture contained in the mixture and to avoid cracks, which are the unavoidable result of a sudden pressure. An excess of compression spoils the fuel, prevents its free burning, and makes the ashes adhere to the surface of the lump, instead of falling through the grate into the ash pan. The fuel must be sufficiently compressed to bear transportation and reasonable handling and be still porous enough to insure free combustion.

The shape of the fuel is also of great importance. Square lumps have too many sharp edges which break off easily when the coal is handled, and the flat surfaces meeting very often in the fire prevent the free access of the air. Cylindrical-shaped lumps are better, still they have sharp edges left. Round or egg-shaped lumps are evidently to be preferred. It is not without some good reasons that this shape has met with favour for nearly three centuries in Europe.

To compress the plastic composition into round or egg-shaped lumps it requires less power than is required to compress square ones of the same weight, as there are no corners to fill and, as a result, less friction. With round or egg-shaped lumps, no matter what amount of coal is piled on the fire, there is always sufficient space between the lumps to secure a good draft and to allow a free access for a good supply of oxygen.

For these reasons I have adopted the egg-shaped form, slightly flattened, and have modified Baudry's and Martin's presses, in order to obtain more and better products. Instead of using moulding rollers producing only one lump at a time, I increase the length of the rollers and mould fourteen lumps at a time. The feeding is regulated by a pug mill, with a central shaft, to which a series of knives is fastened at any required angle, and below these knives, on the same shaft, is a two-bladed propeller. The bottom of this mill is formed by two sliding plates, which can be brought apart and together by hand-wheels. I am thus enabled to increase or reduce the open space between them, and to force more or less plastic material between the rollers, according to the degree of moisture which it possesses. The number of revolutions of the knives can also be increased or reduced by changing one gear wheel, which can be done in a few minutes. A machine is thus obtained, possessing all the good qualities of

Baudry's press and having none of its defects. The lumps fall on an endless wire cloth belt and are carried by it directly into the drying oven. This press will produce over ten tons per hour.

The drying of the fuel, in Europe, takes place in ovens. As I have said before, it falls into baskets or on trays, or is piled up into iron cars having perforated sides and bottoms. Although it requires much unnecessary handling, it must be admitted that with lumps of a considerable size, which remain a long time in the oven before drying, it is a necessity to adopt that system. When large-sized lumps are piled up into a car, sufficient space can be left between the lumps to allow a free circulation of the heated atmosphere, but with lumps of a small size this system will not answer, and that for obvious reasons. If the cars are filled, the lumps at the bottom are crushed by the weight of the coal piled on top. The heated air cannot circulate between the lumps. The coal at the bottom, along the sides, and on the top of the car will dry, while the centre of the mass retains the moisture. Sometimes, as it happened to me twice at Nesquehoning, the coal at the bottom of the car will catch fire, while the fuel in the centre is still moist.

To avoid the piling up of the coal in cars, and to give to each lump the full benefit of the heated atmosphere of the oven, I place five wire-cloth endless belts on the top of one another, leaving sufficient space between them. The belts command each other and they travel in opposite directions the entire length of the oven. The top belt comes directly from the press, with the pressed fuel on it, and it travels the entire length of the tunnel at the slow speed of 12 feet in a minute; five times in succession is the coal carried through the tunnel, falling along chutes from one belt to the other, and it comes out on the fifth and lowest belt perfectly dry. The length of the oven is 100 ft.

The wire-cloth belts are strengthened by wire ropes, placed under them and in the centre. The wire-cloth is fastened to the wire-rope by iron balls cast in two pieces, each half having a recess for the wire-rope to fit in; one of these half spheres receives the wire-rope first, then the wire-cloth is placed over it, and finally the other half is placed on the wire-cloth, and the whole is solidly fastened together by a bolt which passes perpendicularly through the balls. These balls act like the cogs of a cog-wheel, and run in a gutter placed under the centre of each belt, thus supporting the weight of the belt and of the coal on it. Each roller has four recesses in which the balls successively fall, thus preventing the slipping of the belt.

In this system all handling is suppressed. No cars, tracks, hooks, turning tables, &c., are necessary. The doors of the oven are always closed, and consequently the heat in the oven can be kept up to any degree; the iron in the oven is not liable to contraction and expansion, and less coal is consumed to dry the manufactured fuel.

To render the fuel impervious to moisture, instead of mixing a resinous substance with the materials, the lumps are simply dipped into liquid composed of rosin number three dissolved in crude benzine. By exposure to a current of air the benzine evaporates, and leaves each lump coated with a thin film of rosin, which closes all the interstices and renders the fuel waterproof. I have kept lumps under water for three months. Here are some which have been kept for two months in this glass vessel at the American Institute Exhibition in New York. The only effect of the water on the coal is to turn the varnish with which it is coated to a greyish colour.

The working model of my machinery will explain the entire process. The coal-dust is dumped on a platform and pushed into the hopper of a stationary cylinder, in which revolves a shaft having six radiating partitions, dividing the interior of the cylinder into six equal parts. The coal-dust falls between the partitions as they revolve and fills the whole space between them. The rotary motion given to the partitions carries the coal to an opening under the cylinder, where it is discharged. A smaller hopper receives the clay, previously dried and ground. This clay is carried through a smaller cylinder, containing also revolving partitions, and is discharged into the same chute as the coal-dust, with which it mingles. The space between the partitions of each cylinder is calculated so as to allow the discharge of only 5 per cent. of clay from the one, and 95 per cent. of coal-dust from the other. The mixture of coal and clay, while falling under a chain elevator, is sprinkled, in due proportion, with milk of lime from a tank placed at any desired point. This mixture is then raised, in a moist condition, by the buckets of said elevator, above the hopper of a conveyor in which it is discharged. A screw propeller, revolving in this conveyor, forces the materials into the mixer, where they are rapidly worked into a plastic mass by seven upright shafts. To each one of them four-toothed arms are secured by set screws.

Through an opening in the bottom of the mixer the plastic mass falls along a chute into the pug mill of the press, and is forced by the knives and the two-bladed propeller between the rollers, where it is moulded into oval lumps, which are discharged on the endless wire cloth belt underneath the press. The lumps are carried by this belt into the drying oven, through which they travel five times, from one belt to the other. They come out on the fifth and lowest belt perfectly dried, and are discharged into the buckets of a second elevator, which carries them up and discharges them on the waterproofing belt. This belt is guided on each side by balls, and is continually immersing itself and the coal on it in the waterproofing liquid, contained in an open tank. On the sides of this tank are grooves describing a curve; under these grooves the balls travel. This tank is kept filled with the waterproofing liquid, supplied from a larger and hermetically closed tank. The belt has small partitions to prevent the sudden fall of the lumps into the mixture, and they also answer the purpose of raking them out of it. When the lumps come out of the bath, the liquid in excess pours in drops through the meshes of the wire-cloth into a gutter placed under it, and, through a pipe, is collected into any suitable vessel.

To evaporate the benzine, the fuel coming out of the bath is discharged on the top belt of another oven, which I call the evaporating oven. This one is of smaller dimensions than the drying oven, and it contains only three belts, instead of five; they are also placed above one another. A fan forces air through this oven to evaporate the benzine, while the fuel is travelling from one belt to the other. From the third and lower belt the coal falls through a chute into the coal car standing outside. The end of the chute can be raised to allow sufficient time for the removal of the loaded car and the placing under the chute of an empty one. During this operation the fuel collects in the chute, so that there is no time lost.

From the moment that the coal-dust and the clay are thrown into the respective hoppers of the distributing apparatus until the manufactured fuel falls, ready for the market, into the coal car standing outside, the whole process of manufacturing is carried on automatically. During the entire process the fuel is constantly in motion. With fourteen men only, a production of 150 tons per day can easily be attained; two presses would be more than sufficient for such a production.

This model was built at the shops of Albright and Stroh, at Mauch Chunk, Philadelphia, where I tried last week a small press constructed on the principle of the one I have patented. It worked to perfection, and demonstrated conclusively the practicability of my process. These lumps, which are at your disposal, were manufactured at Albright and Stroh's by that machine. They are exactly of the shape and size which I have adopted for stove coal.

I was perfectly familiar with this artificial fuel matter, when I came to this country. I knew the processes tried and applied in Europe, and also the machines which had been used for the application of those processes. I knew their qualities and their defects, and when my attention was called, six years ago, to the immense accumulations of coal dust considered here as worthless, I concluded that I should benefit mankind and myself if I could make of that waste a marketable product.

I went earnestly to work. I met with difficulties of all kinds, pecuniary difficulties, popular prejudices, old-fogy ideas, opposition of coal dealers, opposition of coal miners; I even was called crazy by members of my own family. I often felt low-spirited, but I must say that I was cheered up many a time by encouragements from intelligent and scientific minds.

When I came to Philadelphia, three years ago, I was told that this was not the place for me; that Philadelphians, as a mass, were lacking spirit and business liberality; that no new invention, and especially so in a case like mine where so many had failed, would receive encouragement or support.

As this was merely an assertion, I relied upon my own judgment and experience to find out if its truth was demonstrated by facts. The result of my observations was that Philadelphians were unenthusiastic and somewhat disinclined to accept any new matter on faith, but knowing that, as a natural result, it is characteristic of such a people to hold fast to faith which they have once based on a conviction of merit, utility, and profit, I determined to stick to my task and to remain here. I saw that mere novelty, or loud talking, or humbug of any kind, would not be sufficient to force a matter on the public, but that I had to give substantial evidences of the merits of my invention, of its thoroughness, of its vitality, in order to earn the confidence of Philadelphians.

I made an appeal to the highest scientific authority of this country, to the Franklin Institute of this city, to that institution of which I am proud to be a member, and which never refuses to acknowledge an invention of merit. A committee was selected and a very favourable report was made on my fuel in December, 1870. This, after four years of struggles, was the first powerful lift which decided my success. The process was invented, but only part of the machinery for its application.

It is evident that, no matter its utility, its practicability, and

the profits to be derived from it, an invention must not be presented to the public too hastily, before it has been well digested, or before means have been considered to carry out the proposed end. The inventor must be able to tell the public, not merely that a certain good and profitable object is in view, but that an intelligent plan has been devised for attaining that object, and that the execution of that plan is practicable, that it will benefit the people at large, and also, at the same time, secure remuneration on the capital invested.

To do this I required help, and substantial help. The Lehigh Coal and Navigation Company of this city, at the suggestion of its honourable president, Mr. E. W. Clarke, furnished me with all the means, mechanical and financial, to experiment upon my process. This enabled me to study the matter practically, to ascertain the difficulties which I was exposed to meet in the future, and to modify my machinery in order to avoid those difficulties. For this help extended I publicly express gratitude to the Lehigh Coal and Navigation Company, with whose president and officers generally my relations have been most pleasant and agreeable.

I owe also a debt of gratitude to the press of this city. Publication of the report of this Institute, with very flattering and encouraging editorial comments on my process, have been published in the Philadelphia papers. These articles, republished all over the country, have given to my process the notoriety which it has acquired.

To-day, I am glad to say, these experiments are satisfactorily finished, and the product, I believe, will shortly become a commercial article.

SYNOPTICAL VIEW OF PRACTICAL TECHNOLOGY.

IT has been thought that some general conspectus, or synoptical view of practical technology, comprehending the outline of facts in every branch of industrial art, would be far from unwelcome to the readers of this magazine. Without aiming at any very high degree of detail, the results, paragraphically stated under each head, are therefore now presented.

The enormous strides of technological science have been such as to command the energies of a multitude of investigators, the more prominent of whose names will be found under each heading. These will indicate to the enquirer into special branches the authorities necessary to be consulted for a complete knowledge of the various points here described, while at the same time the general reader can form some more adequate idea of the vast field occupied by scientific technology. It is hardly necessary to preface this synopsis at any great length, inasmuch as every part of the subject is sufficiently independent and self-intelligent for practical purposes. Nor has it been thought necessary to occupy much space in the description of processes which, however interesting in themselves, must needs have expanded what is offered into a complete treatise on the industrial arts. Great care has been taken to include in the briefest and tersest manner, everything which seemed important, and such particulars as are given, have been drawn up with due attention to accuracy. It is therefore hoped that this conspectus will be found useful to the manufacturer and student alike.

Water-wheels and Hydraulic Pressure.

Originally a purely empirical business, it was not until the middle of the eighteenth century that anything approaching a rational scientific method of construction was attained. Antoine Deparcieux, in 1753, first pointed out that the pressure of water was much greater in effect than its mere motive fluid power, and similar results were arrived at by the Italian mathematician Papacino d' Antoni in 1759 and 1762. This led to the substitution of overshot mill-wheels for undershot wheels, principally, however, brought about by John Smeaton of Ansthorpe, near Leeds, who had been making experiments in 1752 and 1753, and who published his results in 1759. The Frenchman Bossut, and the Swede Nordwall, and yet more recently Gerstner, Redtenbacher, Weisbach, General Morin, Count Pambour, Poncelet, Zuppinger and Sagebien, have occupied themselves with this subject. Iron water-wheels were first built in England in the year 1813.

Horizontal water-wheels, driven by the action of running water, have been known for centuries, and are even still to be found in some parts of Europe. But the horizontal wheel of Poncelet, introduced into the south of France about 1826, and the still earlier Danaid wheel of Manoury-Dectot, differs from the horizontal by the water acting by top pressure. Another class is formed by the reaction wheels, the origin of which is to be found in the wheel devised by Professor Segner, about 1750. Euler's theoretical wheel (proposed about 1750 to 1754) has never been practically used. Such improvements as have been made upon his principle are due to Manoury-Dectot, Burdin, Wing, and Passot, the last of which writers brings us down to 1838. Burdin called his wheel the turbine, but under this designation at the present, is chiefly understood the generally used horizontal water-wheel, with its numerous modifications. The first turbine deserving the name was constructed by Benoit Fourneyron, about 1827, and since then with numerous modifications by Henschel, Nagel, and others, it has passed into general use. A very long list of improved turbines might be added, but it will be sufficient to refer to Poncelet (1838), Redtenbacher (1844), and Weisbach (1850), upon the point.

The water column engine no doubt is indebted for existence to the idea of the steam-engine piston. The first of these was attempted, without practical results, by the Frenchman Denisard and his associate, De la Duaille, in 1731, and very soon after by Winterschmidt, in the Harz district (1748), while Westgarth followed in England about 1765. Rischenbach, in the years between 1808 and 1817, improved upon the design, and carried it out on a large scale. We find other engines of an improved description introduced by Brendel (1823), Jordan (1830, 1835, 1849), Juncket (1830), Taylor and Darlington (1842), and Armstrong (1846). These machines have given rise to the modern hydraulic pressure engines in universal employment; and among the constructors of these engines we should honourably name Shoklizh of Lemberg (1846), Lewis, Ramsbottom, Perret, George and Coque.

Windmills.

Since the application of steam for the purposes of grinding, and other uses of atmospheric power in the arts, windmills have fallen into comparative neglect. Still, at one time the subject was one to which the minds of many great practical mechanicians were applied. One of the earliest theorists on this point was Colin Maclaurin (1724), and he it was who first led the way to fortunate practical results. Smeaton also directed his attention to the question of windmills, and especially to the better construction of sails (1758); and a series of observations were also made of great importance by Coulomb about 1780. In more recent times Gustave Gaspard Coriolis (1829), Wersbach (1836), and Laclonge (1856), have illustrated the theoretical aspects of windmills. In reference to improvements in the apparatus little is to be said. Doinet of Paris (1780), Mickle (1772), Bywater (1804), and, more recently, Cubitt, have made alterations in the mechanism, or additions to the number of sails. Horizontal windmills have been projected in plenty, but seldom put to any useful purpose.

Caloric and Gas Engines.

The very great expense of steam engines, together with some of the disadvantages arising from the use of steam, stimulated the minds of inventors to find some cheaper and more effective motive power. Hence we find attempts made to use combined gases, in which steam was to be employed conjointly with other more rarefied aëriform bodies. Thus Dutremblay in Paris (1846) proposed to make use of ether or aldehyd, Lafaud (1848) of chloroform, Seyferth of Langensalza (1857) of carbo-sulphurets. Brunel (1825), and Christie (1856), suggested the employment of artificially fluidified carbonic acid gas. It was long hoped that electro-magnetism might be brought into use as a motive, and Jacobi succeeded in 1839 in propelling a boat on the Neva with an electro-magnetic engine of one-horse power, and Stohrer afterwards succeeded in setting lathes to work by similar means; while Wagner seriously endeavoured to replace steam as a power in locomotives by electro-magnetic apparatus. The very serious cost of such engines has however for the present relegated such machines to the region of philosophical toys.

A much more important part is destined to be played by caloric engines and gas engines. The most recent experiments of Ericsson and of Monchot have demonstrated the possibility of such appliances, in which heated air forms the motive power. The air-expansion engine was first attempted to be produced by Niepce in 1806, and his apparatus was succeeded by one of an entirely different construction, by Cagniard-Latour (1809). An air-hydraulic lift-engine was patented in 1816 by Montgolfier and Dayme. Similar attempts, all of them, however, unsuccessful, were made by Gundy and Naeve (1819), Lilley (1820), and Stirling (1827). The greatest inventor in this direction was, however, the indefatigable Ericsson, who may be said to have devoted his whole life to the pursuit of this branch of machinery. Prehn and Dunn are also names to be mentioned here. Erics-

son's high-pressure air engine was finally patented in 1860, and has since been modified by a host of other mechanicians, among whom we may mention Laubereau, Belou, Schwartz, Kopff, Edwards, Whipple, Wilcox, Young, Kirk, James, Roper, Windhausen, Shaw, Macdonough, Unger, and finally Lehmann, whose caloric engine dates from 1869. The question still remains in an undecided condition, and can hardly be regarded as finally solved.

The gas engine has been the joint invention of Barsanti and Matteucci in Italy, and of Hugon in Paris (1858). In 1860 another engine was brought forward by Lenon, in 1866 Otto and Langen invented a similar apparatus at Cologne. Other modifications, with more or less success, have since continually been made, with very slight practical results.

Steam-Engines.

Like very many other great inventions, that of the steam-engine has passed through a series of phases of development, causing it to be very difficult to say at what time it actually first came into existence, on a superficial review of its history. The period of Hero of Alexandria is sufficiently remote, and certainly the crude experiments of his time are far behind those of which we are now aware. Perhaps it is difficult to define a steam-engine, but if we specifically regard it to be any machine set in motion by the expansive power of steam itself, we shall probably arrive at the best definition. In that case the invention of the steam-engine must be attributed to a period of about 100 B.C. Its practical application, however, does not date higher than the first half of the seventeenth century of our era. Probably Thomas Savery, who took out a patent in 1698, is the most practical person we first find dealing with the steam-engine itself, and the precursor of its multiform applications since that time. The name of the partner of Savery was Thomas Newcomen, an iron merchant, who, with Cawley, formed the three persons who, in co-partnership, produced the first simple steam-engine. This was first used in hydraulic operations in mines, the first engine being employed in pumping in the county of Warwick in a coal mine about 1712. Brighton and Smeaton subsequently made some slight improvements in the steam-engine. All the improvements of this time continually tended towards a re-assertion of the principle of Savery, and it was not until the time of James Watt (about 1768) that this became altered. In the present synopsis it is not proposed to enter into the details of the various engines, but it may be mentioned that Watt undoubtedly was the inventor of the double-action cylinder, and hence the founder of all modern steam apparatus. This principle, long fought for by Watt, was first successfully utilized in cotton-mills, breweries, flour-mills, rolling-mills, and similar branches of industrial science. The Watt engines were, however, all low-pressure engines in the first instance, and it was not until he had made sure of the low-pressure engine that he projected the high-pressure engine. The first high-pressure engines were built by the American, Oliver Evans, about 1801; but Trevithick and Vivian, in 1802, built similar engines, gradually making improvements up to 1815. At the present time high-pressure engines are generally adopted with the additional feature of super-heated steam. Among the great names to be mentioned in association with super-heated steam are Sorel (1844), Detmold (1846), William Siemens (1846), Chaigneau and Bichon of Bordeaux (1852), Lloyd (1852), Wethered (1852), Seguin (1855), Dumery (1857), and Bultin (1860). The Perkins engine of 1822 deserves a separate mention by itself. Among expansion engines we should name those of Hornblower (1781), Sadler (1798), Robertson (1800), progressively improved by Woolf (1804), and Sims (1840). Balance engines and direct engines are to be attributed to Edmund Cartwright (1797), Murray (1802), Maudsley (1807), Saulnier, of Paris (about 1812), Dawes (1816), and others. Oscillating engines are to be associated with the names of Murdoch (1785), Cavé, of Paris (1820), and Mandy (1822); improved structural arrangements having been since introduced. Horizontal cylinders were first proposed and carried into effect by Symington (1801). Rotary engines and agricultural steam-engines have been a much more recent introduction. The principal writers on the mathematical theory of the steam-engine are Poncelet in France (1828), Ravier, Pambour (1835—1839), and in Germany, Redtenbacher.

In the brief view we propose at the present time it would be impossible satisfactorily to give a history of steam-engines and their development, hence we must refer to special articles in our pages, by experienced writers, for particulars. The rise of the locomotive engine itself would form an instructive chapter in industrial progress.

Combustible Materials.

A very important item in all matters of practical technology is formed by the general body of combustible materials for smelting purposes. Hence it becomes necessary to consider this point on the present occasion. In the earliest times, while the forests were dense, and before land rose in value from the innumerable causes resulting from the advance of civilization and the increase of population, wood abounded and was readily convertible by the rudest processes into the charcoal required for primitive metallurgical operations. But from the force of circumstances it became necessary to seek for new sources of fuel supply; and the gradual discovery and adoption of coal as fuel, led also to its being converted into coke, now a positive necessary in many operations of the furnace and the crucible. At what time coke was introduced into general use it is impossible now to say. Although patents for the conversion of coal into coke were granted in England as long ago as 1628, 1633, and 1636, the methods then in use have remained a secret, and appear to have differed, so far as known, from more scientific modes since introduced. It is, however, certain that in 1769 the process of coking was practised both in coking mounds and in closed ovens. Lord Dundonald, in 1781, adopted semi-closed furnaces, with especial reference to the production of tar; and a portion of the heat produced was then unquestionably performed by some of the fuel so introduced. Winsor in 1804 first patented the process of coking in retorts, gas manufacture for lighting purposes having preceded it by a few years.

The use of coal was of very much slower adoption out of England, and its history in this country has already been told in a former article by the present writer.[1] In 1775 there appeared at Lyons an essay on the uses of coal (by Venel, Professor of Chemistry in the University of Montpellier), whence we may gather that much remained to be done in reference to the utilization of this precious fuel. Nor was coal in that country greatly used in metallurgy until the second quarter of the present century; while the same circumstance held good of Germany. The rich beds of anthracite of Pennsylvania were not discovered until 1791, nor were they much used until 1815, and in furnaces at a more recent period. At the present time an almost incomprehensible quantity of coal is consumed in metallurgical works of various kinds, as well as for machinery of all kinds.

Coal, not reduced to the condition of coke, exercises much of its heating properties by virtue of the flame produced in its combustion, and this is naturally nothing else than the incandescent mass of the inflammable gases, developed from coal by the action of heat. These gases may be converted into heating materials by an antecedent process, by eliminating them in a shape capable of preservation, and hence of comparative consumption at will. Gas so obtained can be also directed by pipes into such quarters as may be required, and that was employed in the first instance by Aubertot (between 1809 and 1814). The names of Thomas and Laurens are also to be mentioned in connection with this subject, and the system of Victor Sire soon followed upon that of Thomas and Laurens, about 1836. The same gas system was introduced into Germany by Fabre du Faur, in 1837. The chemical aspects of this question have received the attention of Bunsen (1838), Ebelmen (1839-1841), and Scheerer (1843).

Furnaces.

Furnaces and ovens intended for the production of and purification of metals have been constantly in course of improvement, and it would be difficult to enter satisfactorily upon the details without proceeding at too great length. Reverberating furnaces, however, merit special mention. They have been known in England since 1612, and since that time have come into general use in all metallurgical districts for every species of work. This description of furnace has been of especial importance in iron foundries and puddling works. Siemens' regenerator furnace has been found highly valuable; and an increased size of these furnaces has rendered great service in the rapid production of metals.

Iron.

The early refining and smelting furnaces in which the iron was produced in a rude mass directly from the ore, are nearly all abandoned in practice; the preparation of ore iron takes

[1] See "Coals and Coal Mining," vol. i. p. 196; and "The Coal Fields of Great Britain," vol. i. p. 417.

place in blast furnaces, whence the liquid crude iron issues —these furnaces appear to have first been used about 1600, in the Rhine provinces. But the dimensions of these furnaces have been materially increased, and now extraordinary masses of iron are produced by their means in very short spaces of time. The employment of coal for iron smelting dates some two hundred and fifty years since in England. In the year 1612, Simon Sturtevant obtained a patent from James I. for the manufacture of all kinds of iron with coal; but this patent, as also that of John Stevenson at a somewhat later period, does not appear to have been successful. The first person who smelted iron direct from the ore with coal seems to have been Lord Edward Dudley (1621), and he presented sixty cwts. of iron per week by these means, still no results of any enduring value ensued; nor were the subsequent endeavours of Astell, Copley, and Crofts crowned with greater success. The cause of failure existed in the fact that ordinary coal, not converted into coke, was used. When coke came into use very superior results ensued. The first foundry using coke in the furnaces was that of Colebrookdale in Shropshire, about 1713, but improvements continued to be introduced until 1735, when the system was regarded as perfect. Coke furnaces then came into general use, and were very numerous by 1750, and by the year 1788 nearly seventy-nine per cent. of the whole iron production was accomplished with coke in 1,093,258 cwts.; in 1806, however, ninety-seven per cent. was thus produced (5,088,450 cwts.), as only 2 furnaces in 161 were then burning charcoal. With superior blast apparatus it has been possible, since 1831, to use ordinary coal. Coke furnaces were of much later adoption abroad, the first being set in action at Creusot, and the second at Vienne, in France. In Prussia, the first coke furnace was built at Gleiwitz, in 1796, and in 1798 two other furnaces were erected at Königshütte, near Beuthen. In Belgium, the first coke furnaces were built in 1824, at Charleroi and Seraing. In the year 1838 forty-seven such furnaces existed, together with ninety-two charcoal furnaces. The earliest attempt to make use of anthracite, was in North America, about 1820; hot-air blasts were combined with this about 1833.

However different some special processes may be, the general features of the method of producing iron in blast furnaces are exactly the same. The ore is roasted in the upper part of the furnace shaft; the mass being gradually reduced to a metalliferous condition on sinking down by the carbon and hydrogen of the fuel; this takes up a greater or less quantity of carbon in the lowest part of the furnace, melts and runs together into a rude ferrous mass in a fluid condition, while the gangue fuses into slag. Gurlt of Liége, in 1856, proposed to perform this process in two sections—that of the deoxidation of the ore by means of inflammable gases in one furnace, and the smelting operation in another furnace. Although this has been effected on a small scale in 1857, at Rheinbach, near Cologne, this has not come into general application.

Wrought iron is produced by an extra refining—puddling in puddling furnaces, and so forth. The first English patent for puddling was granted in 1766 to Thomas and George Cranage, but it does not seem to have led to any result, Henry Cort being regarded as the actual inventor, about 1784. William Purnell (1787) also obtained a patent. The grey crude iron masses were further remelted about the end of the eighteenth century in special furnaces. Among the persons who further perfected the art of puddling, we should name Samuel Baldwin Rogers (1816), Karl Emil Schafhäutl (1836), Isaac Hazlehurt (1854), Eastwood, Dumeny, and Lemut (1853, 1862). The use of superheated steam was first proposed by James Nasmyth (1854) and George Parry (1856), and other improvements were introduced by Richardson about 1868. We have not space at command to enter upon the history of the steam-hammer, which now plays so important a part in all iron manufacture. It was projected in the first instance by James Watt (1784), and William Devérall in 1806 also conceived the idea of such an application of power; but to James Nasmyth (1838 or 1839) the honour of completely realizing it is due, although it was actually first practically used at Creusot in France by Bourdon. In 1842, however, Nasmyth improved his original invention, and patented it. At present the largest steam-hammers in existence are those at Krupp's Steel Factory at Essen, and one manufactured at the Cardiff Atlas Works for the Baltic Ironworks at St. Petersburgh.

Steel.

Steel and its method of preparation has been known from the most remote antiquity; but a real knowledge of its chemical constitution was only obtained during the last quarter of the eighteenth century. It was at first produced in a similar manner to iron, and where the antiquated methods of producing raw iron still linger, steel is frequently made. Cast steel was already known in Germany in the middle of the sixteenth century, but steel manufacture was transplanted to England at a very recent period by James Goodyer in 1771. An analogous process to puddling would seem to have lain very near at hand for steel manufacturers, but half-a-century elapsed before this process was actually applied. This was done at Lemburg on the Lemme in Westphalia (1834) as well as at Weyerhammer, in Bavaria; in 1836 at Frantschach in Carinthia; in 1839, at Wetter on the Ruhe; in 1844 at Magdesprung in the Harz, and at Wickede on the Ruhe; 1845 at Geitebrücke, near Hagen, in Westphalia; in 1849 at Eberwald in Steiermark, but without any beneficial results. Puddled steel was first successfully produced in 1850 at Haspe in Westphalia, by the engraver Bremme and his coadjutor, the chemist Lohage (both of Unna). The invention was rapidly diffused throughout Germany, thirteen steel-puddling furnaces being already set in action in Westphalia by 1851. Its introduction into the following countries occurred at the several dates, Belgium (1850), England (by Riepe, 1850, Brooman, 1854, Benzion, 1858), France (1855), Austria (1855), &c. At the present time puddled steel plays an important part in the industrial arts, and at the present time it ranks next in utility to Bessemer steel.

Cementation steel was introduced into England in the seventeenth century by a German workman from the County of Mark, but although it must have been known in Germany long before, that country and France remained far behind England in excellence of manufacture. Vismara of Cremona, in 1824, converted bar iron into steel by its introduction into the retorts of an oil-gas apparatus, and Macintosh, in 1825, attained the same result by means of coal-gas. The widely diffused method of heating the furnaces by inflammable gases was introduced by Aubertot in France about 1810. The principal improvements in this manufacture have been brought about by Tunner (1846), Bremme (1849), Lohmann (1849), Weber (1852), Beauvallet, Jullien, Kreeft (1856), Dixon (1858), Herrzehl (1859), and Eaton of New York (1861).

Cast steel was first originated in England by Benjamin Huntsman, a watchmaker at Doncaster, about 1740, but the development of the industry dates from about 1810. In that year the steel factory of Krupp, at Essen, was established, and the son of the founder, Alfred Krupp, has since raised the establishment to be the largest in the world. Johnson and Barrault, in 1858, in England and France, succeeded in introducing important improvements.

The preparation of steel by melting wrought iron with raw iron was first indicated by Réaumur in 1722, but nearly a century passed before Obersteiner at Murau, in Steiermark, made experiments of a vague and unsatisfactory kind. The endeavours of Heath (1839, 1845), Price and Nicholson (1855), G. Brown (1856), Cowper (1861), and others, seem to have equally been without results.

Returning to the simplest and most natural method, the employment of atmospheric air as a method of oxydation, was proposed and patented by Harrison Aydon (about 1862), and this method was incorporated by Henry Bessemer into his method of producing steel, originally brought forward by him about 1855 and practically realized about 1857 and finally carried on on a large scale. Bessemer steel was introduced into Sweden about 1857, into France about 1863, and at the same time into Prussia and Austria.

Attempts have been made to produce cast steel direct from raw iron by Hawkins (1836), Belford (1854), and Newton (1856), but these attempts have hitherto been unsuccessful. Chenot's system has been also tried since 1854 in France and Belgium, but without effects of a permanent kind.

It has also been thought advisable by alloying steel with small proportions of various other metals, to increase the utility of cast steel, especially in sharp instruments, but this has had no practical value in the industrial arts. Jean Robert Breant (Paris, 1823) suggested manganese, and this was also tried by Heath (1839) and Robert Mushet (1857). Nickel and chromium have also been used (Stodart and Faraday, 1820, Berthier, 1821), titanium (Mushet, 1859); potassium (of some value); copper (Fischer, 1816); silver (Stodart and Faraday, 1820—1822, useless). Some other alloys of small importance have been suggested.

Blast Apparatus.

Many varieties of blast apparatus for metallurgical operations exist, and a continual ratio of improvement is taking place in their construction, or in special applications of mechanism for the more effectual maintenance of a constant and steady blast. This description of apparatus is best divided into *wet* and *dry* blasts. The old-fashioned dry blast bellows has not as yet quite disappeared from smelting works and forges in general. This method is an arrangement of two systems of bellows, acting in an

interchangeable manner. But an ordinary blast bellows can easily be fitted up to produce a constant blast, by connecting it with a weighted wind-bag, which lets off the wind during the time of normal recovery; at which period the original bellows is reinflated. For many years this has been in use, and is known as the double bellows. The invention of this simple, though, apparently, complex bellows, is ascribed to a locksmith named Freytag about 1724. It was improved and rendered more constant in its action by Mohr of Koblenz (1828), Prudel of Troyes (1833), and Paillath of Paris (1836); but a superior modification was made by Braun of Marburg at a later period. The triple arrangement has since been effected by De-la-forge (1813) and Rabin, also of Paris (1831). Poivat in 1809 altered this movement into a system of standing bellows, which contained the wind receptacle in the centre, thus affording a constant double blast of alternate action. The method adopted by Jeffries and Halley comprehended the inclusion of an air-tight wind chamber with two pairs of bellows of the ordinary kind, the latter driving the wind contained in them into the wind receptacle by reciprocal action. The plan suggested by Powell (1825) was that of a series of horizontal bellows, driven on a vertical axis, being eight in number; but this has been generally looked upon as both cumbrous and ineffective, although it was intended that the apparatus should be self-acting.

The expense and unenduring quality of great leathern bellows led to the invention of wooden bellows, which, externally resembling the simple leather bellows, were formed of separate moveable chambers, the walls of which were formed by thin tablets of wood. These are of very ancient introduction, and it would appear unquestionable that they, at any rate, existed so long ago as 1550 in Germany, when they were known at Nürnberg; they were also to be found in use about 1620 in the Harz district, and at the end of the seventeenth century they were carried by a German into France, being also unknown in England at that time. From 1730 they were generally used in Germany, and about the beginning of the present century, they were improved by a Swede named Widholm, and known as the Widholm bellows. We have also the English drum bellows, invented by Powell (1825); and from this many other kinds of bellows have originated. The cylinder blast was invented by Smeaton about 1760, and first used in an iron foundry in Scotland; afterwards these bellows were generally used in England. The mining engineer Furiet improved upon this arrangement about 1855. The most modern of these adaptations is the one known as the centrifugal or ventilator bellows. Authorities upon the subject are Terral (1729), Daelen (1843), Lloyd (1848), Chaplin (1853), Ristinger (1858), Bourdon (1862), Heger (1862), Perregault (1865), Reichenbach and Golay (1869), and Brakell in London (1869). We should also mention the ventilating blasts of Reuleaux, originally devised by Davies, Roots and Evrard, anterior to but not later than 1867.

Water has been employed as a motive agent in blasts; we have the bell blasts acting somewhat on similar principles to the gasometers; an improvement on this is the Baader cylinder blast, made known in 1788-1794 and 1799. The Migeon blast patented in 1827 corresponds with this in a marked manner. Wet blasts of various kinds have since been constantly introduced, by Hachette in 1828, Caigniard-Latour in 1812, improved by Martin in 1834. Lüders also invented a similar apparatus (1828), carrying it out on a larger scale in 1834, and Ruchet has, about 1860, brought out an analogous engine at Paris. The chain blast of Henschel also merits due attention. The latest modifications are those of Neilson, Macintosh, and some others now greatly in vogue.

Silver.

As pure and rich silver ore is of such very uncommon occurrence they are seldom specially smelted—thus almost all the silver is obtained from poor silver ore, or from lead ores containing silver, and also from copper ore. The winning of silver is therefore almost always combined with that of lead, or copper, or both together; hence the processes are necessarily very much involved one with the other, and of reason must differ according to locality. The winning of silver by amalgamation (invented in Spanish America in 1557) was introduced into Hungary by Ignaz v. Born (with the modifications suggested by Barba at Potosi, 1590); was improved in 1786, at which time Gellert suggested the method afterwards amended by Charpentier. Cupel furnaces (for the separation of the silver from the lead) were first introduced in the Lower Harz in 1712; the use of coke (in place of wood or charcoal) has subsisted in Freeberg from 1820. Another process is due to Hugh Lee Pattinson in 1833, for the speedier extrication of the lead in the form of crystals; the method of Parkes (1850 to 1852) is also greatly in vogue. Other experimentalists have been Becquerel (1834), Percy (1848), Augustin (1848), Gurlt (1850), and Lebel (1824).

Gold.

Gold never having been found in a native state without some intermixture of silver, it naturally follows that there is an intimate connection between the processes adopted for the presentation of these metals. After other ruder processes it becomes necessary to separate these two metals, and for a long time the methods adopted were unsatisfactory and expensive, much gold remaining mixed with the less costly metal. The processes indicated by D'Arcet in 1802, and improved by him in 1816, have been found the most practical.

Platinum.

The first specimens of raw platinum were brought from America to England by Charles Wood in 1741. Scheffer, of Stockholm, describes the metal in 1752 as "white gold," and inquirers into its constitution soon sprang up. Among these we may note, William Lewis, of Kingston, Surrey (1753); Andreas Sigismund Marggraf (1757); Macquer and Baumé, of Paris (1758); Cronstadt (1764); Bergman (1777); and Sickingen before 1782. Achard (1784) was the first to discover that platinum was capable of being wrought, and he was the first person also to produce a platinum crucible. The manufacture of platinum was, however, first carried on by Chabanneau and Jeanetty in Paris about 1787. Pelletier (1789), and Mussin-Puschkin (1800), materially improved the mode of extricating platinum, although their employment of phosphorus instead of arsenic met with little encouragement. The most important change in the treatment of platinum ore was, however, effected by William Hyde Wollaston (about 1804). Breant, of Paris, had a process known to himself alone for the production of platinum. Hess, of St. Petersburg, recommended the melting of platinum with zinc in 1848, and its subsequent treatment with nitric acid. In 1852, Deville finally succeeded in smelting platinum in blast furnaces with coke firing. Other authorities, &c., Debray (1857—1860); Heräusy and Matthey. Platinum has been manufactured into jewelry, being plentifully alloyed with silver.

Copper.

The ordinary method of smelting copper from siliceous ores has undergone little or no modification, although improvements have been effected in the construction of furnaces and other adjuncts. At Nischnei-Tagilisk, in the Ural, about 1856, Nordenskjöld introduced a mode of using vapour during the roasting of the ore, and thus aided in the desulphurization to the extent that black copper was won at the first operation. Keates in the same year desulphurized crude copper by the assistance of hot-air blasts, introduced during fluidity. At Wotkinsk, in the Ural, in 1868, an attempt to adapt the Bessemer process met with success. The roasted silex was melted by Napier (1806), with Glauber salts, carbon and soda, thus producing sulphate of copper. Rivot and Phillips improved upon this process in the same year.

Lead.

The use of coal in the lead smelting furnaces appears to have been in use in England about the middle of the seventeenth century, at least patents were granted for the purpose in 1623, 1678, and 1690. Coke has been employed since 1816.

Zinc.

In the earliest times, the only application made of zinc was in the preparation of brass. Zinc in a pure state was first brought from China (under the name of Tutenag), in 1596. It was a metal very little known, and formed an article of import from the East Indies until the end of the eighteenth century; since 1815, however, this circumstance has been reversed, and much European zinc has been exported to the East. It is asserted that zinc was won in England as long ago as 1730. Swab found zinc among the ores of Dalecarlia, in 1740, and in 1743 the Bristol zinc works were established. But the creation of zinc as an industrial staple in Europe must be placed at the end of the last century. In Carinthia and Silesia, we find attempts made to produce zinc about 1798; in Belgium, it became an established trade about 1807, through the long-continued exertions of the Abbé Dony; in Silesia, the industry materially increased from 1808; at a much later period (especially since 1852) it was introduced from Belgium into the western provinces of Prussia. The elasticity of zinc was proved by Sylvester and

Hobson, in Sheffield, in 1805. The authorities upon zinc and its treatment are Troughton, Graham, Benecke, Shears (1847), Dyar (1838), Jefferies (1840), Duclos (1838), Normandy (1847), Rochaz (1847), Bussy (1857), Müller and Lencauchez (1860), and Lesoinne (1850).

Tin.

Stratifications of tin are found of enormous wealth in India, especially upon the peninsula of Malacca and some of the adjacent islands, such as Banka and Biliton. In Europe, tin is only as yet found in quantity in Cornwall, although Saxony and Bohemia contain tin lodes. Robert Lydall (1702) is associated with the furnaces for the winning of tin. Partridge, in 1782, improved these furnaces. At a later period, alterations were effected by Michell (1843-1852), Polkinghorne (1845), Oxland (1847), Emerson (1853), and Pierce (1861). Duclos, Budd, and Phillips, are also honourably associated with better methods of purifying tin.

Nickel.

This metal was discovered by Axel Fredrik Cronstedt, the mineralogist, in 1751. It was long before it acquired any commercial value, although it now enters into many branches of manufactures. Gersdorff, of Vienna, in 1825, first established a nickel factory at Reichenau, near the Schneeberg, in Lower Austria. His nickel, however, contained much iron. At the present time, nickel works exist in many places, such as Schneeberg, and Annaberg, in Saxony; Iserlohn, Sangerhausen, in Prussia; Naunberg, in Silesia; Isabellenhütte, near Dillenburg, in Nassau; Aurorahütte, near Gladenbach, in the Grand Duchy of Hesse; Joachimsthal, in Bohemia; Schladming, in Steiermark; Kitzbüchel, in the Tyrol; in Hungary; and at Birmingham and Swansea, in England.

Aluminium.

Argillaceous clay, or alum earth, which forms an important constituent, not only of clays and of alum, whence its name, but also of many other mineral substances, is the oxide of a metal now known as aluminium. It was recognized as such by the chemists in 1807, by Davy, who had proved kalium and natron to be metallic oxides, and thus by analogy had inferred a similar composition of the earths. But the isolation of aluminium was only accomplished at a much later date, when Wöhler in 1827 produced it as a grey powder, and in 1845 in the form of white shining globules of the size of a pin's head; in both cases the quantity was excessively minute. As an industrial product it was not known until 1855, when it was first exhibited at the Exhibition in Paris; its introduction into commerce is due to Henri-Etienne Sainte Claire-Deville, professor at Paris. The fact that aluminium is found in so common a substance as clay would lead it to be regarded as a very cheap metal, but as it cannot be directly obtained from clay, but has to be extricated by means of a very tedious and expensive process, aluminium is an expensive metal.

At the beginning of 1855, Deville was instructed by the Emperor Napoleon III., who defrayed the expense of the experiments, to undertake a scientific inquiry into the economical production of aluminium at the Chemical Laboratory of Javelle, near Paris, and he was able thus to obtain several pounds of the metal in an impure condition. Subsequent experiments, in which Deville was associated with the brothers Rousseau, led to aluminium being produced at about 300 francs per kilogram, reducing the original cost to less than one-third. After much labour in France, a further reduction in price was effected, and on the introduction of aluminium manufacture into England, where Messrs. Bell, since 1860, have been engaged in its production, it has been produced at forty shillings the pound of troy weight. Cryolite (a Norwegian metal), and Bauxite (of which large quantities were found in the south of France), have since been used with aluminium, and it has now become a standard article of manufacture for jewelry, chains, pins, and similar articles. The trade is no doubt capable of indefinite extension.

Copper Alloys.

These fall into three groups; the representatives of which may be regarded as brass, bronze, and argentine, or German silver.

Brass, which mainly consists only of copper and zinc, is distinguished into yellow brass, and tombak or pinchbeck, according to the greater or less quantity of zinc contained in it. Both of these metals have been known from remote times, although zinc is of quite recent introduction. This curious circumstance is to be explained by the fact that long before it was possible to present zinc in a pure state, brass was made with minerals containing zinc oxides, the zinc being reduced during the process of smelting in order to unite it with the copper. Silico-carbonate of zinc and galena was used until a later period of the first quarter of the nineteenth century; the more rational and now universal employment of zinc itself could only ensue when zinc became a general article of commerce, although Emerson had indicated zinc for this purpose as long ago as 1781. Galena was used, and a patent granted to John Champion as long ago as 1758, but its employment was suggested as something new even as recently as 1818, by Boucher in France. Authorities on this subject are Lund and Hawksbee (1728), Rosthorn (1825), Muntz (1851), and Arch (1860). All sorts of copper alloys have been introduced, such as princes' metal, pinchbeck, semilor, Mannheim gold, chrysochalk, mosaic gold, chrysorine, orcide gold, and other substances.

By bronze is understood a mixture of copper and tin, and copper, tin, and zinc, for cannon and bell metal, and also statue bronze, together with the bronze for smaller objects afterwards varnished with gold, or actually gilt. Bronze is also used in some parts of machinery. Brunton (1844) invented a kind of bronze consisting of 3 parts of copper, 2 parts of zinc, and 1 part of tin for the manufacture of cast shovels. A composition of 100 parts of copper and 5 to 7 parts of tin has been used since 1830 for the sheathing of ships. Bronze, with a considerable admixture of tin, according to the observations of D'Arcet (1813), has been found to possess a certain degree of malleability and great toughness after being plunged in cold water at a dark red heat. It is thus that cymbals and other brass instruments are prepared, and it is also the common procedure in the striking of bronze medals. Chrysochalk is used for sham jewelry, and consists of copper with 5 per cent. of tin, and since then Talmi gold has been introduced, containing besides copper, 4 per cent. of tin, or 5 to 10 per cent. of tin and zinc. Bronze has been also largely introduced into coinage. The dates are Switzerland (1850), France (1852), Sweden (1855), Denmark (1856), England (1860), Italy and Belgium, (1861), North America (1864), Egypt (1866), Norway and Roumania (1867), Serbia (1868), and Greece (1869).

Copper has also been attempted to be alloyed with aluminium; in fact, various alloys of the latter metal having been tried with copper, the so-called aluminium bronze contains about from 3 to 10 per cent. Its durability has been found very great, and it has been also of much use in wrought products. There is only one objection to aluminium, and that is its very high price.

Argentine, German or Chinese silver (Pakfong), is an alloy resembling silver, formed of copper, zinc, and nickel. This was originally prepared by the Chinese from a remote period, and presented a white metallic surface. Its composition was analyzed by Engestrom in Sweden in 1776, in Edinburgh by Fyfe in 1822. It was first used by the Prussians at the arms factories of Sahl, near Erfurt, for mountings for arms, spurs, and military accoutrements. A prize was offered in 1823 by the Society for Industrial Trade at Berlin for the invention of an alloy to resemble silver, but to cost only one-sixth in price. This led to the simultaneous production of argentine by the Brothers Henninger in Berlin, Geitner in Saxony, and Gersdorff in Vienna, and has since formed a branch of commerce in all parts of the world. Some other copper alloys of less consequence are in existence.

Tin alloys are perhaps the next in commercial value since the introduction of Britannia metal, consisting of tin and antimony. An alloy of tin, lead, and bismuth, forms a very easily soluble mixture. On this topic it is desirable to consult the original experiments of Homberg (1699), those of Valentin Rose, in Berlin (1771), of Jean D'Arcet (1775), and Gerardin, in Rouen (1845). The American Wood has very recently added cadmium to this alloy for several useful purposes. White metal was introduced by Dewrance and others about 1844, and forms an admirable metal for taps in engines, axle-boxes in locomotives and similar contrivances.

Zinc alloys have usually been treated by the addition of small quantities of metals, calculated to diminish the natural brittleness of the metal itself. Thus, according to Fontaine-Moreau (1838), small portions of copper or cast-iron, separately or together, have been added, and proportionate parts of tin and lead. The ship-sheathing metal of Revere (1830) consists of zinc with five per cent. of copper. Zinc, tin, and a little copper, form the component parts of the antifriction metal of Fenton (1844); zinc, tin, and a portion of antimony, iron, or copper form the metal of Parkes (1844), employed in articles to be silvered by galvanic processes.

Amongst lead alloys, it is only necessary here to refer to antimonial lead used for cast vessels, and which vessels require to be painted.

As it is not designed to enter upon the full description of the

various processes connected with industrial manufactures, it may be sufficient for the present occasion, having considered in their series the metals and their alloys, to speak of the finishing operations to which they are subjected for various practical purposes, and even of these it will be impossible to name more than the most important.

CLEANSING.—Sulphuric acid is now universally used in the cleansing of metallic substances from the oxides adhering to the surface, but, supported by experiments made by Sorel, Thomas and Delisse (1848), it has been shown that the addition of certain organic substances, such as glycerine, napthaline, and creosote was of great utility. However, L. Elsner, of Berlin, in the following year substituted for these expensive products the far cheaper article of coal tar. This is even more successful than the employment of a galvanic apparatus, proposed by Symonds and Mouchet in London (1852). In the analogous process necessary for brass, Rust suggested dipping in a solution of chloride of zinc, drying by heat, and washing with water. In dead brass nitric acid is used with effect. The whitening of alloyed silver is produced by boiling in diluted sulphuric acid.

POLISHING.—This process is performed by natural and artificial stones, first introduced from Hindustan in 1838 (being an artificial conglomerate of corundum and shellac); this has, however, been superseded by cheaper processes introduced by Malbec (1843), R. Müller and Dollinger, both before 1854. Polishing stones of emery powder and clay have still more recently been introduced into commerce by Merkelbach and Stadelmann. Other hard substances are however in use.

PLATING.—The art of plating metals with others has been considerably improved since the middle of the eighteenth century. The tinning of copper vessels with fused tin was known in antiquity, and is mentioned by Pliny (who died A.D. 79); but the tinning of iron (not so easily performed) is first mentioned by George Agricola. It seems to have originated in Bohemia, and was carried by a priest into Saxony, about 1620. About the year 1670 one Yarrenton was sent from England to Saxony in order to learn the art, and in 1691 Edward Heming was granted a patent in England for the manufacture of tinned iron of equal excellence to that produced in Germany. Other improvements, rendering it possible to carry on this manufacture on a very large scale, have been made by Leach and Willett (1859), Budd (1859), Hughes and Williams (1859, 1860), and many more. Galvanized zincing was introduced by Sorel in 1836, Elkington and Barrat of Birmingham (1838), and Böttger (1840). The coppering of iron is due to Ruolz (1841), and to C. V. Walker (1845). The process of John Poole was patented so long ago as 1816 and 1821.

GILDING.—Of all systems of overlaying, the art of gilding is the oldest and most noble. Pliny describes the process, although in an imperfect manner. In the middle ages the art was frequently used for fraudulent purposes, and led to an Act of Parliament, in 1403, by which the sale of gilt brass and copper utensils was forbidden. In the year 1663 the process of gilding steel or iron which had previously been plated with copper was known. The sublimation of mercury leading to extremely bad results to health in consequence of the vapour, attempts were made to diminish the danger consequent on the process. The experiments instituted with this object by Hill in London (1774), and the goldsmith Chambrier in Geneva (1780), have never been preserved; even the better apparatus of D'Arcet (1818) has found very little application. Elkington's process (1837) is, however, still well known. To Robert Southwell, about 1698, is to be ascribed the merit of the cold process so far as England is concerned; it is said that he derived it from the German goldsmiths. The other chief processes are those of Peyrand and Martin (1854), Stodart (1805), Bonnet (1838), Levol (1843), Peaget and Dubois (1846), Smee, Roselene, and Christofle (1863), and Frankenstein (1842).

SILVERING.—The older methods of silvering have almost gone out of practice since the introduction of galvanic silvering which speedily took root among the manufacturers after the invention of the gold galvanic method, about 1840. It is useful to note the process of Mourey (1843) which, to a great extent, obviated the yellowish tinge observed in wares subjected to the silver galvanic process. Another mode of treating the metal to be silvered originated with the chemist Stein of Dresden in 1847, especially for objects not fitted for dipping.

PLATINIZATION.—Whatever may be done in this department is as yet so slender in results that we cannot point to any satisfactory experiments, however carefully conducted. Although platinum is extremely ductile, the expense of the material seems to have precluded chemical treatment.

GLAZING AND ENAMELLING.—This process for glazing or enamelling cast-iron vessels was invented by Sven Rinman, a Swedish metallurgist, in 1783; in 1799 Hickling took out a patent for it, but the very great difficulties which lay in the way of a realization of the process retarded its perfection for many years, so that, according to a report of the year 1828, nothing of permanent utility had been effected at that time either in England or France. But very good enamelled cooking vessels had been produced in Germany between 1815 and 1820 at Lauchhammer, in the county of Merseburg, and thence the manufacture was carried into Silesia, especially at Gleiwitz; the fabrication of such vessels was also carried on about 1822-1825 in the Austrian States, at Horzowicz in Bohemia, Blansko in Moravia, and Troppau in Silesia. Patents were still being taken out in England and France in 1839 and 1846. It would be impossible to enter upon any detailed account of bronzing, lacquering, and other processes, from the multiplicity of appliances in use for this purpose, and the same observation applies to varnishes, paints, and other matters.

IRON AND STEEL WARE.

NAILS.—The simplicity of the form of nails soon led to its being thought possible to manufacture them by machinery, but the practical realization of this industry was attended with many difficulties, while it was difficult to compete with the economy of workmanship and the skill displayed by hand nail manufacturers. Machine nails are usually supposed to have been first made in North America, where patents were granted to Perkins (1795) and Grant (1811); but it would seem that England is undoubtedly entitled to priority in this invention. Between 1790 and 1852 no less than fifty patents concerning this one article of manufacture were issued, and in 1809 we already find machine nail factories established in Birmingham. Cast machine nails are associated with the names of Thomas Clifford (1790), Todd (1818), Syndall (1827), Tyrrell (1840), Gautier (1855), and Carron (1857). Other apparatus was patented by Wies and Grodmann (1844), Hopper (1855), and Lussigny and Wassilewski perfected the Ryder nail engine. We also find Fuller (1834), Stocker (1836-1840), Lambert (1848), Croisy and Pidancet (1854), Laurent (1863), and Gustafson (1862). Cast nail machines were brought out by Guppy (1796-1804), Spencer (1801), Dyer (1810-1812, 1814), Todd (1818), W. Church (1818-1831, 1832), Wilks and Ecroyd (1825), Ledsam and Jones (1827, 1831), and B. P. Walker (1844). The first French nail-making machines of any value were those of Lemire (1817), and subsequent inventions have been made by Stolle (1830), Massiaux (1845), Bacaresse (1849), Brezol (1850), and Gervaise (1866). In Austria cut nails were first made by Schafzahl (1815) with Schmidt's machines; while Leppich, Wurm and Dostel have also made improvements in this manufacture. We also find the machinery of Lolot (1835), Mallet (1844), Danks (1853), and Dawans and Orban (1852). Small cast-iron nails of very cheap quality have been made for many years past, Joseph Ashton having taken out patents for the purpose in 1769 and 1771.

WIRE NAILS.—The first wire-nail machine was patented in 1811 in France by James White, but it was never carried into effect; and in 1816 Daquet followed with a machine the nature of which is now only partially known. Malliot (1822) made some improvements in the wire nail manufacture, and between 1822 and 1854 at least forty patents for this industry were taken out in France.

PINS.—Probably the oldest pins fabricated received their heads by means of hammering or punching; in the sixteenth century the head was formed of fine wire, and between 1680 and 1690 the globular pin-head was first introduced. Birkby of Leeds in 1835 re-modelled pin manufacture, but a really new period for this industry arose with the introduction of machinery for the purpose. Prominent amongst the names of the inventors of machinery for this purpose are those of Seth Hunt (1817) and M. Wright (1824), Slocum (1835), Coates (1840), Renaud (1844), Lusty (1852), Rauschenbach (1859), Fowler (1860), Ledsam and Jones (1831-1833), Migeon and Schervier (1813), Jenkins (1841), and Huet and Geyler of Paris (1848).

NEEDLES.—If the technical processes connected with the manufacture of needles existing a century ago be compared with those at present in vogue, we not only find important improvements in portions of these processes, but an absolute difference in the principles on which the manufacture is conducted. The changes relate especially to the application of machinery in place of hand labour, and upon procedures by which swiftness of production is increased. The newer methods have also had a material effect in diminishing the danger to the artizans employed in the needle factories. The steel dust has been removed by various devices: in 1813 Prior proposed to use bellows for this purpose; Westcott (1817) and Abraham of Sheffield (1821) suggested the use of magnets for its collection; while Elliott, in 1823, enclosed the grindstone in a case and blew the steel dust away by a current of air. H. Walker (1848) proposed that the grindstone should be surrounded by a wet woollen covering in

which the dust should be caught. The chief authorities upon this subject are Ledsam and Jones (1833), Birkby (1836), Schleicher (1858), Milward (1813), Lusty (1865), Walters (1864), Nicholson (1859), Morrall (1839), and James (1853).

HOOKS AND EYES.—The first machine for the manufacture of these articles was invented by Hoyau in Paris (1827), and he was followed by Moiselet of Lyons in 1830, W. Church (1840, 1842), Böck (1841), Gingembre (1843), Peyrouse (1844), and Dengl.

FISH HOOKS.—The principal improvements in this speciality are due to Milward of Redditch, who, in 1853, invented a machine for their production. The machine prepared 15,000 in a day, and workmen can perfect these at the rate of 3,000 per day per man.

WIRE CHAINS.—Machines for manufacturing wire chains of iron and brass for use in machinery were invented by Vaucanson. Seider in Vienna, 1833, invented another, and a third was brought out by Cochot of Paris, in 1829. A peculiar and powerful chain was invented by Wright of Glasgow, in 1839, who also patented special machinery for its production.

WIRE ROPES.—The first application of wire rope was made in the construction of light suspension bridges. Spun wire rope, similar in method to hemp rope, was first made by Albert in the Harz in 1834 for mines; A. Smith, of London, introduced them into England in 1839, and Hirn, in 1854, first applied them in machine work. Since the introduction of telegraph cabling much attention has been given to this subject. Machines for wire-rope making have been invented by Wurm in Vienna (1837), Newall of Dundee (1840, 1843), Heiman (1841), Smith (1849), and J. B. Wilson of Heydock, Lancashire (1849). The first attempt to make a wire rope of cast steel was that of Vennemann at Bochum in 1852. Telegraph cable work has been principally confined to England, taking its rise about 1852.

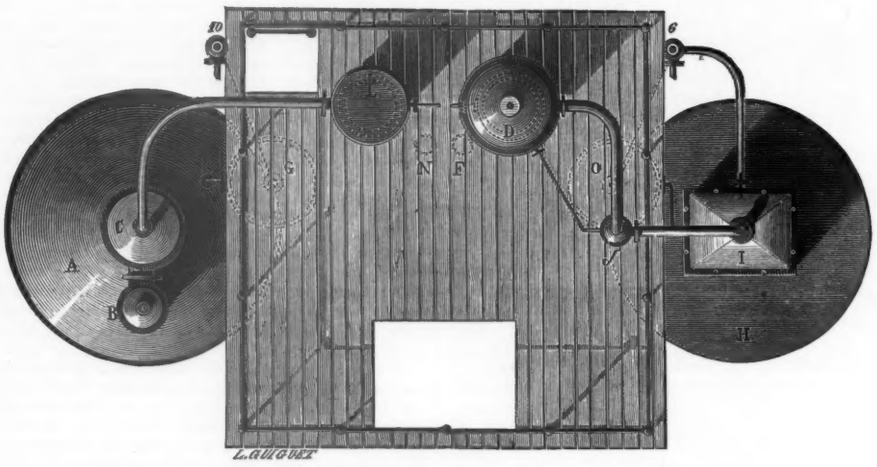
WIRE NETTING.—Wire netting of brass and iron, usually used for sieves, has since received an extended application (such as endless shapes for the production of machine-wrought paper, in corn-cleansing, and flour machines), and it has also been used for window-blinds, baskets, lamp-covers, tea-strainers, masks, &c. The pressing of wire netting into shapes was invented by Allard, of Paris (1821), and was afterwards imitated by Gosset in London (1823), and Philippi in Vienna (1825).

COINS AND MEDALS.

The art of coining embraces two closely related and yet widely differing branches of metal work, namely, the production of money coinage and that of memorial medals. The technical processes are common to both, but coins have to satisfy several conditions not necessary to be considered in medals, such as the utmost exactness of the alloyed fine metal and the weight of individual pieces; whereas in memorial medals the chief necessity is allied to artistic beauty of detail, which naturally falls within the domain of the designer and the engraver of the die.

We will first turn our attention to coins. Gold, silver, and copper continue to be the chief metals, as of old, from which money is coined. Platinum is of very recent introduction, and is only used in Russia. The minting of gold and silver in a pure state, or in one almost pure, is now very much less in practice than it was in ancient times; and after the adoption of numerous alloys with copper in the eighteenth and nineteenth centuries, the average has now been fixed at nine-tenths of gold or silver and one-tenth of copper. Silver coins are alloyed with a mixture of copper, zinc, and nickel. Copper is now minted with tin and zinc, and sometimes nickel, thus giving the coins a harder surface, and preventing the rapid wear of the impression. In 1858, some coins were brought out in England of two different metals, namely, gold with copper rims, and silver with the same; but this was only experimentally done. The machinery for coinage would be best described by itself, as it is foreign to our purpose to enter upon it at present. The process of striking medals resembles that of coining in most particulars.

K. R. H. M.



PLAN OF THE DISTILLING APPARATUS OF SAVALLE, SON, AND CO.

DISTILLING APPARATUS.

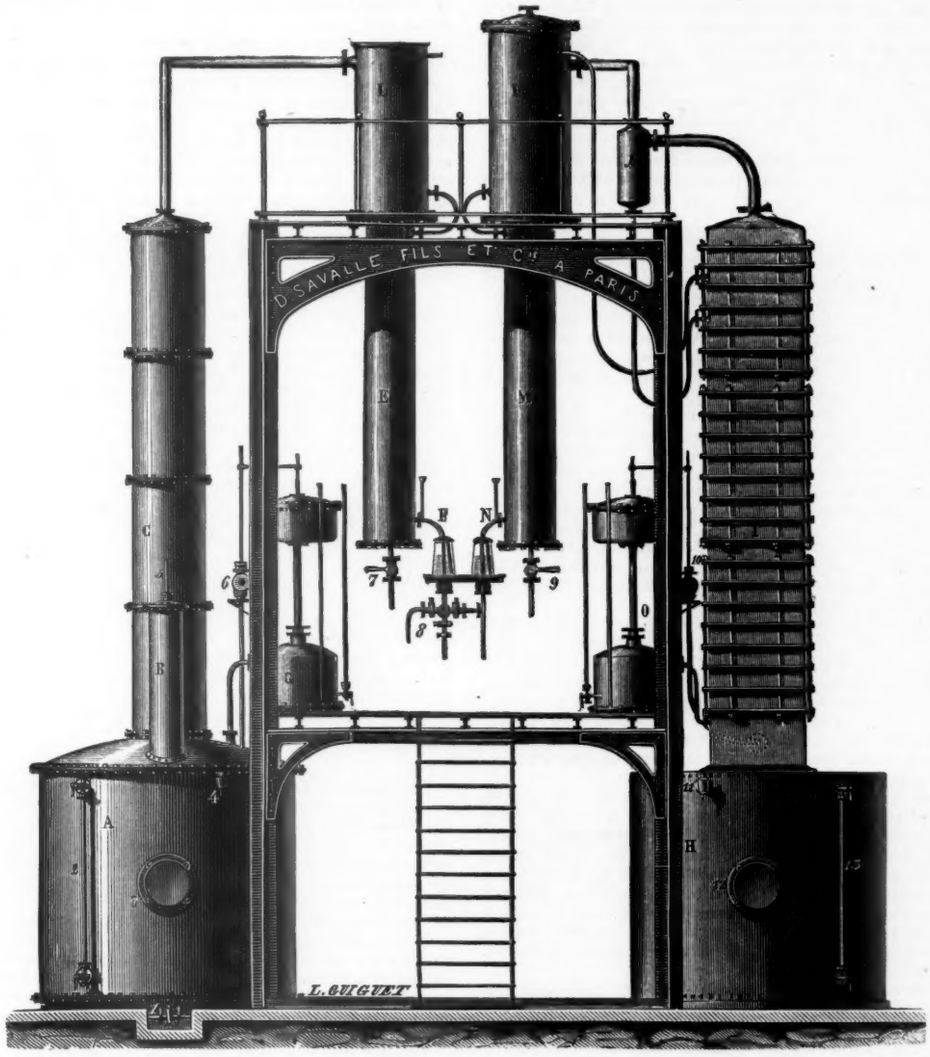
NUMEROUS specimens of this class of apparatus were exhibited at the Vienna Exhibition; but perhaps one of the most interesting and valuable was that shown by Messrs. Savalle, Son, and Co., of Paris, who have so distinguished themselves in this branch.

We give a general view and plan of their apparatus, but for details must refer to an interesting pamphlet by M. Désiré Savalle, on "The Recent Progress of Distillation" (Paris, Georges Masson, 17, Place de l'Ecole de Médecine). It contains matter deserving the attention of all concerned in alcoholic distillation as well as the preparation of aniline colours.

We may note that Messrs. Savalle up to 1872 had supplied their apparatus in various parts of the world to an extent representing a daily production of a 1,500,000 litres of alcohol.

Whilst the Vienna Exhibition remained open twenty-eight of their large-sized apparatus were ordered for the following countries:—

Egypt (for the Khedive)	5
Russia	4
Holland	1
Portugal	2
Austria	3
France	7
Rio Janeiro	1
England	1
Germany	1
Rhenish Bavaria	1
Spain	2
	28



GENERAL VIEW OF THE APPARATUS FOR THE DISTILLATION OF FERMENTED LIQUOR AND FOR THE RECTIFICATION OF ALCOHOL BY SAVALLE, SON, AND CO., PARIS, AS EXHIBITED AT VIENNA.

ARTIZANS' REPORT UPON THE VIENNA EXHIBITION.[1]

(*Continued from p.* 205.)

WOOLLEN CARDING.

Scouring and Preparation of the Raw Material.

THE first special feature is the very great care taken in freeing the wool from grease, burrs, seeds, &c. Wool scouring was well represented by Messrs. McNaught's, of Rochdale, well-known machine, which is of great advantage compared with the old and slow process of hand-washing. The wool is then dried and willowed ready for burring, for which a very efficient machine is exhibited by M. Celestin Martin, Verviers, Belgium.

Burring Machine.

The principal novelty in this exhibit is the burr cylinder, the diameter of which is about 24 inches, covered on the surface with thick-teethed bars, similar to doffing-plates, which are ground to the surface, admitting of very close setting of the burr roller. Between, and from the roots of each tooth, grooves are cut about $\frac{1}{16}$ of an inch deep and broad to run out at the back in the direction of the circumference. The points of each succeeding row of teeth are brought immediately opposite the grooves. The effect of this arrangement is, the wool being caught by the teeth falls in the grooves, which are too small to admit the burrs and other hard matter; consequently, the burrs being on the surface are very readily knocked off with very little wool attached.

Oiling and Fearnoughting, or Plucking.

For these purposes M. Martin exhibits machinery. This process of oiling is far in advance of the English system of putting the wool on the floor in layers, or beds, and sprinkling on the liquid with an ordinary watering can, when the blend is run through the plucker, and sometimes the willow, thereby losing a large percentage of oil. This oiler distributes the oil on the material as it passes finally along the lattice feed-sheet of the

[1] Published by the "Society for the Promotion of Scientific Industry."

plucker. The machine has two cans, quarter circle in shape—one for oil, and one for water—having a spout at the bottom of the straight side. The cans are placed above and across the feed, and are tilted by means of a rack and cog-wheels. The liquid when released runs into a gutter with niches cut one inch apart across the feed. A quick revolving brush, about 12 inches diameter, sprinkles the oil in a gentle spray on the wool as it passes along the lattice on the feed-rollers. When the machine is stopped, or running without wool, by simply tilting back the cans the flow is stopped. Should an oil containing sediment be used, it would be liable to make up the niches, and so prevent its proper working.

Feeding.

M. Martin's set for fine work.—This set consists of three single cylinder engines. The breaker comprises 1 licker-in 10 in. diameter, with burr roller, 1 small breast 10 in. diameter, with 2 workers and strippers 3 in. diameter, clothed with flat wire or Garnett tooth-cards. Cylinder 44 in. diameter, 8 workers 7 in. diameter, 8 strippers 2¼ in. diameter, 1 angle stripper 6 in. diameter, 1 fancy 15 in. diameter, 1 doffer 16 in. diameter, stripped with a fly comb.

The intermediate and condenser carder are of the same dimensions as the breaker, but without the breast. All parts made of iron. The roller bearings are of flat shape, with a square hole to assist the sight in setting. They are put through grooves in the bends, and the side adjusting screws are placed above the top of the bends, and in the way of easy setting. The strippers and fancy are turned outside. The worker chains inside pass over, and are kept clean by a fixture brush.

The condensing machine is on the same principle as that fitted to Messrs. Platt's exhibit, with the exception of turning off 120 threads in place of their 96.

The breaker is fed by a machine consisting of a box or hopper (placed in front), and will hold from 20 to 30 lbs. of wool. Inside this box is a leather sheet inclined towards the engine, on which are placed iron hooks about 2 in. apart. Over the top of the sheet is a roller, with strong straight teeth the same distance apart, revolving at the rate of 12 revolutions per minute, acting as a worker in spreading the wool, which is then passed on to the feed rollers by a fan. This is a very simple arrangement, and lays on the wool far evener than by hand.

The sliver from the doffer is wound on to a blanket feed or endless sheet, passing over and around a series of rollers. After a certain number of revolutions, a bell rings, intimating to the minder that the web is the required thickness, who then breaks it across, and it is weighed on the intermediate by hand. The same kind of feeder supplies the condenser, excepting that the web, when broken across, is wound on a roller, and placed on the feeder the same way as it is turned off the intermediate, not attaining that desirable crossing of the web as shown in Messrs. Platt's exhibit.

M. Martin's set for coarse work.—This set comprises two single-cylinder engines, each part having five workers, of the same dimensions as the set just described, and having the same condensing machine turning off 60 good threads. In these two sets, to prevent dirt and fly accumulating in the necks of the bearings, the roller shafts work in a loose boss about 2 in. long, having a small lubricating cup on the top, and underneath the boss is a small hole to admit a pin fixed on the bearing to keep it in position.

Cards.

The fillet cards on all these machines, which are used to such advantage by the Continental manufacturers, are the Belgian or hard cards. The wire is set in a strong foundation of leather, or seven-ply of cotton cloth, cemented together with a solution of rubber, and filled up to the bend of the card tooth with a woollen felt. The bend of the tooth is so arranged as not to hook the wool, and, should it be overpowered, will sink under rather than rise and make a prickle, a fruitful source of noppy yarn.

These cards are much finer in counts and wire than ordinary English cards. The breaker cylinder is clothed with 22's, or 11 crowns, 110 counts, 32 wire; doffer and workers, 24's, or 12 crowns, 120 counts, 33 wire; the strippers on every part are clothed with undercut diamond point, 6 crowns, the point of teeth rising about one-eighth of an inch above the foundation. The fancy, with sheets, 7 crowns, 70 counts, 32 wire, 2¼ in. cut; the tooth is bent so as to bring the point very forward, so that the contact with the cylinder will be rather at the back than at the point of the tooth, which prevents an excess of fly. The intermediate cylinder is 24's, or 12 crowns, 120 counts, 34 wire; doffer and workers, 26's, or 13 crowns, 130 counts, 35 wire; fancy 8 crowns, 80 counts, 34 wire; condenser cylinder, 26's, or 13 crowns, 130 counts, 35 wire; doffer and workers, 28's, or 14 crowns, 140 counts, 36 wire; fancy, 8 crowns, 80 counts, 35 wire.

Grinding.

For grinding workers and strippers, M. Martin has an excellent exhibit, arranged so as to grind a needle point on the card. It consists of two discs, or face plates, rotating and traversing across the frame, the card roller revolving at a quick pace; the abrasion on the wire by these discs grinds a needle point instead of a chisel or flat point. The traversing strickle exhibited by Messrs. Platt is also a very useful and good arrangement for grinding perfectly true, and can readily be applied on the cylinders and doffers. Should these cards at first or afterwards be ground too hastily, or with too much pressure, serious and irremediable injury is done, as the point of the tooth once brought forward, it is never got back to its place again. If they are properly put on and ground, they are, in effect, as true and level as an iron roller turned in a lathe, and have nothing to prevent them from being set with mathematical precision; they will work so close as only to admit a flat piece of steel of the thickness of 34-wire gauge between cylinder, workers, and doffers, and with this precise setting it is impossible for a lock of wool to escape being worked.

That the British manufacturers are far behind the Belgians and other Continental firms in the production of fine wool yarns suitable for making flannels, shawls, some kinds of fine cloths, and goods suitable for the making of female attire, is very evident, from the published and well known statistics of their large trade in Scotch yarns, having beaten the home firms almost out of the markets; of course, this does not apply to those isolated manufacturers here who have successfully applied this system. It seems to rest in some persons' minds that the wages question enters largely into this matter; but I can affirm from actual inquiries on the spot that it has very little or nothing to do with it, as the following example will show. In works where they employ three women at 6*s.* each per week, we have two at 10*s.* each, and here three men at 20*s.* each per week against their five men at 12*s.* per week, and so on through other departments; from this it is evident that wages do not make the difference.

Ceramic Ware.

The great number of exhibits and the very limited time at my disposal rendered the task of reporting upon the pottery in the Vienna Exhibition a serious one; but I have endeavoured to give an idea of the principal articles exhibited on each stand, pointing out their excellences and defects, and where new paths are being struck out, and of the results obtained. The great advance made in the ceramic art during the past twenty years, and the high art now applied in its manufacture, require not only the technical knowledge of the artizan, but also the experience of a trained artist, to give an adequate estimate of the numerous articles exhibited. The views expressed are honestly given, and if I have in some respects failed to combine the judgment of the two, I must plead the great difficulty of the task.

On my return journey I took the opportunity of a few hours' stay at Dresden to visit the Royal Works, knowing that a short account of some of the processes, &c., would be interesting to some of my fellow workmen.

Japan.

"Japan is one of the most interesting of all the countries that send pottery. First stands the Tamango ware—a buff earthen body, with a rather dull glaze; the style of decoration upon it is beautiful indeed to any one taking a delight in Oriental art. There are some teapots and cups without handles with what a potter would call a defect in the glaze; it is crazed all over in very minute lines; not like the crackled china so called (for that is a crack upon the surface of the ware to the depth of the sixteenth of an inch), but this is a surface craze in the glaze, and it helps to tone the general colour of the ware. The colours have an opaque appearance, but the drawing of the flowers is very pure. In the same class of ware is a complete breakfast service; it is the best of any of this sort of ware. The details of the flowers painted upon it are clouded at intervals with minute dots of gold, which help to take from it the bareness of the surface of the body. I should like to see some of it in England, so that our workmen might see a specimen of Japanese decoration.

I am surprised to see so many things in the case based upon Western outlines, as is the case with almost every other thing. I am sorry to see it, for we shall lose all the charm of the pure Japanese style. I suppose they find it profitable to please the European taste, as I understand they are manufacturing it to order as fast as they can; but the new Japanese make will

not touch the old, when they worked for the love of their art. There are a few of those cups and saucers with covers to the cups, which are a wonder to a potter; what system they had of firing them and yet keep them so straight, and in the making of them keep so regular in thinness, is a mystery.

China.

From this country a very large collection is shown, and, coming from the Japanese Court, all the porcelain looks hard in colour; the colours are more opaque and harder in the lines of drawing, and there is not that minuteness of decoration. Two garden seats, with a celadon glaze and raised white *pâte-sur-pâte* flowers, very beautifully arranged; I cannot exactly tell how it was done, the celadon was kept so clear from the white flowers. There are a number of garden seats, one with a yellow green glaze very good in colour. Several spill cans—the design a bundle of bamboo canes; it was well arranged, and coloured to suit the canes. A square-top flower vase, with little berries on a stem made by hand, and laid upon the vase, is very good in its arrangement, better than we often see such things done in England. Some teapots and cups, with groups of flowers in very pale tints of grey on a beautiful blue, are the best I have seen of the Chinese in this style of colouring. A *déjeuner* set, with square tray, in the yellow ground they are so fond of, with flowers raised upon them; the harmony of colour was wonderful.

India—Madras.

There were some beautifully designed large slabs for a wall in terra cotta, well worth a careful study as an illustration of Indian art. The interlacing flower pattern is perforated. I do not think they were moulded, but am of opinion that they were cut out by the maker. I wonder none of them had been selected for the museums. Coloured majolica tiles were shown, and the style of art was very good, pure Indian, but rather rude in manufacture.

Russia.

Of the Government works represented in this Exhibition the first place must be given to Russia for showing progress. All on the stand is well shown, and the stand itself is one of the best I have seen for displaying pottery. It is covered with purple. I should think the leading artists employed are mostly French, from the treatment of the painting and the outlines of some of the vases. There is an absence of the large vases Russia used to show. All shown here are moderate in size; most of them are mounted in ormolu, and the painting of the flowers upon them deserves the highest praise; the gradations of colour in the backgrounds of the vases, beginning at the plinth in one shade and the top in another, and yet not affecting the general composition of the design, was perfect, and had a good effect, but it would not do for an inferior artist to attempt such treatment. There are two slabs of raised flowers made by hand, very well grouped (much better than some we often see in England), but the flowers themselves were not any better.

I must mention some Moorish tiles, &c., shown by the Government of Russia in the nave of the building. They are of the fourteenth and fifteenth century, and are splendid examples of Moorish design. They had formed parts of a cornice and of a pillar. There had not been any moulding of the pieces, but the maker had put the clay into the shape, and cut the design out of it; the undercutting was so deep, and the drawing of the design so good. The pieces were made by an artist, not by a machine or mould, as most modern things are. It had a charm of its own that made one linger round it.

Hungary.

"*Moritz von Fischer.*—This manufacturer showed more on his stand than any other of the Austrian Empire, and I hardly know how to describe the exhibits, there were such a mixture of all styles and makes of porcelain dinner sets, tea sets, and dessert sets, as thick as they could be put, and all copies of old Dresden, Sèvres, Capi de' Monti, old and modern Worcester, Minton's and I think everybody else having a name for making porcelain. But they are very bad copies; I did not see a good made piece among them—the plates and saucers are fired so badly, and with such an inequality in the surface, and all the plain parts on the sides of the jugs show us the pinching of the fire. I saw the Prince of Wales had bought a tea set of perforated porcelain in the Chinese shape, and with a perforated lining inside; the handles of the pot and sugar box were also perforated, and the set was certainly the most meritorious work upon the stand. But the set had a clumsy appearance, the pieces being too large for what they were intended. I saw a copy of a well-known dessert plate with a perforated edge and cupids painted in the bottom, manufactured by Messrs. Minton. If the artist who did the original were to see this copy, he would be rather shocked at the travesty made of his design. The Capi de' Monti ware was quite as bad a copy; very different from the same style of ware shown by the Marquis Guiori in the Italian Court. The best painting was some figure subjects on plates and a few slabs; the colours were brighter than the rest of the things, but with a hard look upon it. Several large fruit dishes, copies of some of the ugliest Dresden things I ever saw, with a lot of labour upon them. If they would only copy the good things, I could understand that. There is a large vase about five feet high, with a Chinese outline and perforation upon it, covered with dark blue; it was something to remember. I saw that many of the things are sold to German nobles; I hope they will keep them in Germany.

Wilhelm Zsolnay shows a small collection of tea and breakfast sets; the pieces are made better than those of the other firm. Some are painted in the Japanese style, but the colours are poor and the effect weak. He also shows some earthenware vases, the flowers on which were painted in coloured glaze upon the biscuit surface with a very novel effect. This stand had a naked appearance when once contrasted with its overcrowded neighbours.

Austrian Empire.

G. Heinz.—On the stand of this exhibitor were shown groups of flowers painted in the first place on a slab, after which the background of the slab is cut away from the flowers, which are then laid upon dark velvet, the stems being indicated by marks made upon the velvet; it had a good effect. I made inquires about it, and was told that the background is all cut away by a grinding wheel. If so, it would entail a deal of labour; but the china made in Germany could be cut after the first fire very easily, as it has made scarcely any contraction then. I fancy all this stand is the contribution of working decorators. There is a pair of flower-pots done very well with pure Renaissance ornament in colours. The pieces of flower and figure painting are not very good. There is a small pair of vases in imitation of *pâte-sur-pâte*, done with enamel, which is a fair attempt. There are several slabs of groups of flowers, but the colours look hard, and they have much to learn before they can take their place among good flower painters.

V. Kosch, Vienna.—A decorator of porcelain in Vienna. Specimens of dessert plates, nearly all decorated in the Persian and Indian style, but the heavy colours lack that brightness seen in the English. The light tints are better, but most of the designs are a leaf out of Owen Jones's *Grammar of Ornament*. He also exhibits a tazza, made in terra cotta, upon which is painted a female head in enamel, very well done, with a deal of freedom in the drawing, and bold shadows; but the colours partake of the earthy look of the terra cotta.

Ferdinand Beck, Decorator of Porcelain, Vienna.—This decorator exhibits some tea sets with a black ground and fine gold lines upon the white, done with a lot of labour in a style the Germans gilders are fond of; the contrast of colour seemed too severe, the lines of gold being too fine to warm the black.

Franze Kadler, Vienna.—The exhibits on this stand are of a superior character. There are two saucers with raised gold decoration upon a blue *du roi* ground; the raised gold is as good as any specimen I have seen, better than the average raised gold in England. One specimen is treated like the dessert plates at Kensington Museum from the Royal Works of Vienna. I do not think that it is worked with the pencil; one could almost think it was stamped out and fastened with a flux in the enamel kiln, the markings of the leaves and flowers are so sharp. The other saucer is decorated in the Raphaelesque style upon a blue ground; very good indeed. A plate also in the same style of ornament, with the raised part of the panels in silver; it looks rather cold, but it is surrounded by plenty of gold. The figure subjects in colour are painted with good broad effects. Altogether I am pleased with this stand. It does not show a good thing mixed with a lot of poor things, as so many of the stalls do.

I saw several large exhibits of Vienna album and bookbinding firms, and in the covers of the large albums were shown applications of the flower painting with the backgrounds cut away, as on the pottery exhibited by G. Heinz, above described. I was pleased to see what a beautiful and good adaptation it was of porcelain used in the decoration of other articles. On one stand, belonging to Edward Becher, the group of flowers had long twining stems that could not have been fired with the flowers, but the joining was well done. There were groups of Cupids done in the same way; of course there was not the same difficulty with them as with the flowers, the figures being close together. The leather upon the covers was cut out to admit the porcelain, the meeting of which with the leather was close, very neat, and of an even flush surface. You could hardly believe your own eyes, it looked so beautiful,

the dull tone of the leather and the bright colours of the porcelain. I understood that those shown by E. Becher were done by a firm of decorators of porcelain, in Vienna, *Radler and Pily*, who exhibited other things.

Alois Klammerth, Znaim.—I was attracted by this stall. There were excellent mugs and pots shown in common brown and white ware. The surface of the ware is covered with a brown dip, and then upon the lathe the colour is cut away in patterns (some of which are very good), leaving the white under to show the cut of the lathe. I think our common-ware makers might take a pattern from it with profit; it carried a good glaze upon it. Some of the designs you almost thought had been copied from Owen Jones's New Zealander ornaments. The same stall showed some fayence in the Italian style, very good in its way, but displaying no art.

Mahren, Bohemia.—There were three exhibitors of earthenware from Bohemia, some brown and white inside, the glaze not so bad. Toilet and sanitary ware were exhibited by two of them, but they were very small. The dinner ware was very indifferent, and was covered with lustre. There was an attempt at an Indian pattern on one set, which would have frightened an Indian if he had seen it.

In the same Court were a large variety of stoves (used in the German houses), made in terra cotta of different colours, and white earthenware glazed. They are made in several pieces, and I was surprised to see how well they fired the parts and fastened them together with cement. Some of them were well designed, I should think by architects, and others were but poor in design. I wonder they do not make more sanitary ware in the same ware, for it seems to be suited for large pieces. Most of the stoves were very creditable to the manufacturer. There were three different makers of yellow ware in this Court with the black dip outside and the pattern cut out of the black; but it was not to be compared to the production of Alois Klammerth, of Znaim.

Fisher and Mige, Porcelain Manufacturers, Carlsbad.—As a manufacture in Germany, the exhibits of this firm show more advance than any other German manufacturer at the Exhibition, both in ornamental ware, and in goods for the regular market. There is one special feature in this stand. It is the introduction of what I was told was platina in the decoration, but it looks more like aluminium or oxidised silver. When it is used among the gold, it produces a good effect, especially upon some of the ground colours,—the dark blue the best. The design and modelling of most of the things are done without the attempt to do something out of the common way, which often leads to failure, and the making and finishing of the handles in the ornament department were well and carefully done, and much better than most of the pottery from abroad. There were three vases shown in the Egyptian form, with an Egyptian landscape painted upon each in a quiet tone of colour, which were very good. It is a class of decoration I should like to see more of. There are some vases with a beautiful shade of maroon, amounting almost to a purple, with two shades of the same colour worked in a pattern upon it. It is a new colour to me, and it had a fine effect. The lustre decoration shown is much better in its treatment than I see attempted in England. There are several sets of dessert and dinner ware, the making of the plates and the hollow pieces of which was very good. The shapes and decorations were more like the English ware, and the price also was moderate. I think it could compete with us in the English market. There is toilet ware shown: the shapes are copies of the English—one an Indian pattern with a dark brown ground, so much used by the Germans, and another with a pale blue ground, the blue being very level in tone and decorated in good taste; the price was also very moderate for the labour upon it. Several tea and breakfast sets have the dark brown ground. It is a colour that wants careful treatment, and it would not do for any but a proficient to use it. The breakfast saucers are raised in the bottom to fit the inside of the foot of the cup. This stand altogether shows a good collection of almost all that a leading manufacturer would show, and I was pleased to see such healthy progress made.

Berlin Royal Works.—I was much disappointed with the exhibits of this manufactory; for, with such good artists attached to the works, and not the competition of the trade to contend with, they ought to take the lead in developing new processes and productions; but I see hardly a single attempt to do either. Almost all upon the stand had been to the Paris and London Exhibitions. It may be that the late unhappy war has stopped the production of fresh things, for it must have disorganized all industry, especially art workmanship. The most noticeable was a plain line vase, about 2 ft. high, which has not been exhibited before; and the artist who painted the flowers upon it deserves every praise, for I have seen no flower painting in the Exhibition to surpass it. There is good freedom in the drawing, and the distribution of colour is well balanced to keep the outline of the vase. There is also a breakfast set, the design of which, I believe, is by a German Prince, sent by him to the Royal Works to be executed. It is without decoration, is in the rococo style, and is left to its own merits of outline and modelling. I hope it will not find its way into one of the museums to guide the taste of the German potters. There are the usual large biscuit busts seen so often. The large oval body-vase they have exhibited before, with the fine figure painting upon it, the same make as the one at Kensington, except that the handles are in porcelain instead of ormolu; the handles are beautifully modelled, and you can see the modeller has finished the clay handles upon the vase, all the markings being so keen, and no marks of a pencil to destroy the shadows. The gold is put upon the biscuit handles, and you can hardly tell it from the ormolu handles.

The small painted biscuit figures shown are better than those from Dresden. Some Dresden outlines shown are, I suppose, made from the moulds which Frederick the Great had from Dresden. There was a large tripod-shaped vase put on the stand while I was there, nearly 3 ft. across, with the handles in the corners of the angles. It was well painted with foliage in rich soft tones of colour, but I think it was a mistake to carry the colour on to the handles and the edge. At first sight it looked fayence, and if the edge and handles had been finished like the foot, it would have shown the white porcelain. It was well potted, and gives us an idea of what they could do when they made an effort to produce fresh things. With it came a pair of vases, in shape the same as others on the stand, with a snake coiled in the hollow of the foot, and painted with Cupids in a panel of gold leafage, all on the white, very chaste and very good. All the fine figure painting shown is worthy to rank among the best productions of porcelain painting. A large table top, more than 3 ft. across, shows the superior talent of the artists who are employed. The stands of Dresden and Berlin were canopied with red, emblazoned with gold, and looked very imposing, but certainly were not suitable to show decorated porcelain.

Villroy and Boch, Rhenish Prussia.—It was with great interest I looked at this stand, for upon it was something quite new to me, showing the creating art of the potter, in taking the commonest of earthy clays and making from it objects of rare beauty without the aid of gold or enamel colours. The pieces shown are made in a fine terra cotta; the body is buff, with a good surface, and, having a ring, it showed it had been well fired. There are several differently-coloured terra cottas used in combination, the shapes and decorations are of the Renaissance. They are very like a French modeller's work. There is a large rosewater ewer and stand, the ground colour of the rim of which is a dark sage green, and the Renaissance leafage work is raised in white upon it, and well it is done. I think the white is put in the moulds in the slip state (they are not made in a separate mould) and laid upon it; but some of the colours in the ewers are inlaid, for by carefully looking I could see a slight difference in the contraction. There is a pair of vases with two shades of the buff body, a red and a pale blue, some of which colours are used upon the surface in embossment, and some inlaid; but the taste shown in the combination of the colours and in the outlines of the vases is very good indeed, far beyond the ordinary run of new things; it was quite refreshing to see a fresh treatment of outline. Two small ornaments for jewel-stands, I think, are as good in design as the vases; all the handles and joinings are made and put upon the things very carefully. I should like to see all the terra cotta things upon this stand brought to England, for there are several workers in fine terra cotta now in England who would derive a profitable lesson from them in art as applied to pottery. Nearly every piece was sold to the museums on the Continent, but I did not see that any were bought for England; for real merit these productions are far before the great bulk of fayence, which is bought daily because it is the ware most in fashion.

M. Lehomburg, Berlin, shows a variety of insulators, made in a good, hard, china body, with an excellent glaze. Most have an inside tube, and are corrugated, the bolt hole the same; but they show some without the tube. They are well made, and turned all over, and the clifting is deeper than those we now use in England; otherwise there was not anything in the make of them new to us. There were porous cells and tubes, with a white porous body made similarly to the English.

Saxony.

Dresden Royal Works.—It was with disappointment I saw the exhibits of the well-known Dresden porcelain; it was well arranged upon the stand, but most of it has been seen before. There were the usual groups of figures they have made for

years, very carefully done, but all small, with much labour, for which they do not make any great show. I do not think the details of the decoration upon them were as good as those on the old examples. There was a group of vases in imitation of the Limoges enamels. The dark-blue ground was not good, and the enamel had a thin look with no depth of shadows upon it. Altogether it was much inferior to the other examples shown in the Exhibition. The flower painting shown upon some vases, with a Roman outline, is very good indeed. It is rich in tone, and the colour is far in advance of anything upon the stand, and displays the talents of an artist who would be an honour to any manufactory. The plates and dishes were not made and fired very well. They exhibit their perforated dessert plates, so well known for shape, the painting upon which is very good, but it is [no advance upon what they have done before. There are large vases, covered with raised flowers, which make it impossible for anyone to see the outline intended, with all that kind of modelling upon it they are so fond of. I think that the Royal Works ought to take the lead in art, and not keep to the manufacture of a style long since condemned.

Sweden.

M. Gustafsberg, Stockholm.—There are two exhibitors of porcelain, earthenware, and Parian from Stockholm. These two are the only manufacturers of our English Parian body showing here. The principal ingredient, felspar, is found in Sweden, from which country we get most of our supply. M. Gustafsberg shows a number of Parian figures, some original and others similar to those made by English houses, well modelled, but pinched and contracted by the fire about the limbs of the figures to a greater degree than in the English Parian. I could account for this on seeing a broken figure upon the stand. They cast the limbs quite solid, in doing which I suppose they thought they were giving support to the figure in firing, but they are under a great mistake. The colour of the Parian is good, and carries a good surface to show the shadows of the modelling. There is an earthenware dinner set, of which the shape of the covered pieces is better than is usual, and the light blue print upon it is very good indeed; the engraving of the plate is a credit to the engraver, and the print itself is far before any I have seen from a foreign exhibitor of earthenware. There was the usual large vase in earthenware; the form was not new, and the ground colours were thin and poor. Side by side were some pieces of good design in the decoration, but next were some quite as bad as the others were good; there must be some one at the manufactory well up in decoration, judging from the examples shown, and I cannot account for such bad designs being here. There is a dinner-set with a blue sprig under the glaze—a copy of one the Danes sent to the Exhibition of London in 1871, but it is not as good. There is a dinner set with an attempt at Persian form and decoration, having a raised border in Persian ornament on the edge of the piece. It had a rude hard look, and the intention was better than the execution. There are a few things in porcelain, but the decoration was not good enough for the ware on which it was employed.

Denmark.

There are three exhibitors of a fine terra cotta, all from Copenhagen, and there is a great deal of merit in all of them. The body is in pale red, the shapes are principally copies from the antique; they are well thrown and turned, and the handles are carefully made and finished. The decoration upon them is in colour, with Greek frets and honeysuckles, very carefully done. Some of them have flowers of a conventional form in colour, and the painting of the flowers is very good, it did not hurt the forms of the antique vase at all. There were jugs and a pair of vases having Assyrian ornaments painted in colours upon them. The form of the vases was very suitable to the style of decoration. I was much pleased with them; nothing vulgar in the treatment of the colour, as is often seen in such things. All the forms shown were good; none of them were large, and where they had departed from the well-known shapes of the classical, it was done with excellent judgment. They asked a good price for the articles, but they were worth it.

Italy.

The Marchese Guiori.—This manufacturer has a fine collection of porcelain and fayence, and makes a speciality of the Capi de' Monti porcelain. I believe one of the ancestors of the present marquis bought the moulds from the old works near Naples, and I should think most of the things shown are from the old moulds; the potting of them is very good. There is a square box with two large mugs, having the figures, which are well grouped, raised in relief and then coloured; the colouring is done very carefully. There are several large vases in the same style, the figures on which, in high relief, are well and carefully made, and the fire has not pulled them about as badly as some of the others in porcelain: there is a large amount of labour upon them. Two large ewers shown are fine examples; and a déjeuner set, with the exception of the saucers, is well done. I think some of the Capi de' Monti shown are as good as the old in the Kensington Museum, but I know it is difficult to carry in the eye such things in making comparisons.

Almost all the porcelain is well got through the kilns, which shows that there is a good potter upon the works. The gems of the stand were two slabs painted with the Virgin and Child; the tones of the colours were very soft, and they must have been drawn by a real artist. They were much admired. A pair of vases with a pale ground looked as if there had been a white surface or coating laid upon them, and then the pattern was sketched afterwards and cut away till it showed the colour beneath; it was a Renaissance diaper pattern, and it had a good effect: in the hands of some artists it could be made very effective. There was a group of vases in dark blue glaze, traced all over with gold lines to look like filigree, but the lead in the glaze had spoiled the blue. There is a sample of the insulators made for the Italian telegraph; it seemed a pity to employ such a beautiful body and glaze for such common purposes, they being made in porcelain. All the insulators have tubes, and the belt hole is not corrugated. The clefting at the top is very deep, and there was not anything about them superior to the English.

Antonio Scappino, Civita Vecchia, shows a collection of terra cotta, principally copies of old Etruscan shapes. Some designs of their own are as good as any I have seen of the modern productions in terra cotta. The water bottle, with a black decoration, was particularly good in style and finish, and I do not wonder at the speedy sales they made.

Monaco.—A court outside the main building of the Exhibition was devoted to this small State, and the principal exhibits are very noble fayence. Almost all the things were copies of Dresden vases, about 2 ft. high, and covered with flowers made by hand, which were coloured in different shades of lustre, the body of the vases being done with fayence decoration. They had quite an imposing effect, and must have been much admired, to which the large number purchased can testify, some being actually for museums. If we consider their merit as art productions, I am afraid we are making a retrograde movement.

France.

M. Rousseau, Paris.—This exhibitor shows some earthen dinner-ware in a buff body, the colour of which would suit some of those English writers upon art who have lately written about the proper colour for dinner-ware. It is darker in colour than the C. C. ware made in England, but not so clear in the tone, and it shows the sparks of iron through the glaze. The decoration, also, would suit some of the writers referred to; it is birds and flowers, painted with broad shades of colour in a sketchy style, the drawing of which was very free; but I do not think it would do for general sale in England. The shape of the plates is not good, nor of the covers of the tureens and vegetable dishes. The edges of the plates are finished not unlike the manner in which they finish the grass-edge common plates in England. There were several articles finished the same as *pâte-sur-pâte*, but they did not look better than fayence and were not worth the making.

Jules Houry, Paris.—This exhibitor has a good stand of porcelain, applied to the decoration of metal and high-class cabinet-work. He exhibits some good effects, chiefly noticeable being some slabs of porcelain let into jewel-boxes and the tops of tables. The slabs are modelled with stems and leaves, in low relief, and then covered with a beautiful blue glaze; the colour is wiped off the high parts of the modelling, and looks as if the light had fallen across it, and the blue falls into the shadows. It must not be compared with the majolica made in England, which is similar in treatment, for the tone of the blue was bright and pure, and the design suited the purpose. It gives us an idea of what good things can be done without much labour. There is a flower-pot done with a dead-black ground, on which is modelled a simple spray, twining round it. It is well designed, and the spray is covered with the same blue. The unusual fresh appearance which it had added to the advantages of its make. There is a porcelain slab, about 22 in. by 10 in., in a panel, with a female figure, representing painting in porcelain. The conception of the subject is very good, and tells its own tale; and the painting of it is beautiful. A cover of a small box, with a landscape painted on it, in different shades of blue; the colours are good, and the glaze the same. Also vases shown in fayence, of which the handles are in ormolu, and the glaze and colours are richer in tone than most of the fayence shown; it also did

not look so earthy. I should like to see the English use their decorated porcelain in objects of use more than they do; for this exhibitor shows what can be done with it.

Od. Hache and Pepin, Sahalleur, Vierzon.—This firm sends nothing but porcelain; it is by far the best stand of porcelain sent by France, and comes up to our notions of what to expect from her. There is a dessert service very chaste and good in the decoration, but the shape of which the French must be fond of, as I have seen it at three of their stands. A dinner set shown with the oval shape covered pieces is very good; the body and glaze are splendid, and all the pieces are well made and fired. I see the dishes are longer and not so wide as ours, but they look well, and are, I think, better than the oval shape we use. There are some vegetable dishes shown, smaller in size than the English, and with coloured grounds upon the covers; I have not seen colours at home which could compete with them for depth of tone and levelness. The shades of colour were different from those we see so often in England. There was a maroon with a purple cast in it (but not with that washy look which we get in England), and a pure light green, but solid in colour. At first sight they looked as if they were under the glaze, and attracted much attention, as well they might. The knob of the vegetable dish was a rose knob covered with gold, and burnished all over, but it very much detracted from the decoration upon the dish. One of the vegetable dishes was decorated with Persian ornament upon a turquoise ground, and for real decoration I have not seen anything to surpass it—a dinner set done with that decoration would be something to remember. There was a dessert set with large, flat, oval comport dishes having perforated edges; the design of it was good Renaissance, and it was beautifully modelled and made. I must not forget a déjeuner set in pure white china mounted in ormolu; the surface of the pieces was covered with fine lines of modelling, similar to what I have seen on the egg-shell ware of the Chinese; the glaze upon it was very level and transparent. There is a beautifully shaped cup and saucer, with four panels in the line of it and fine fluting; it is a fine piece of potting. There are two vases with ormolu handles, the lines of which are very bad, and the decoration not such as I should have expected, judging from the workmanship displayed on the other exhibits shown on the stand. Altogether it was a relief to see this stand with good porcelain upon it, after seeing so much of the fayence with the dull body and colour, and not half the merit in the manufacture of it as this porcelain.

E. Collinot, Paris.—This exhibitor shows a splendid collection of fayence worthy of the name. The columns on which the covering of the stand is supported, the frieze, and some of the side panels were made in fayence. The large vases made in the Persian style are well designed, and suitable to the decoration put upon them; some of the relief is modelled upon the surface of the vases, but most of it is worked on with the pencil; some in the clay state, as *pâte-sur-pâte*, and some with thick enamel glazes. All the colours are very clean and bright, and are quite a relief to the eye, after seeing so much of the Italian style of fayence. On the back of the stand are two panels about five feet long, made with tiles fitted together and painted with Persian foliage, a fine example of decoration. There are some tiles with raised modelling upon the surface, more like the old Moorish tiles of Spain than any I have seen; I almost think they are copies. They have a good appearance, and are different from the ordinary look of tiles. This exhibitor seems to have mastered the difficulty of the crackled ware of the Chinese, for there are slabs shown crackled all over, which would be difficult to tell from the Chinese; I do not see the use of it for decoration, except when applied to the imitation of the Chinese vases. All the things shown upon the stand are on a large scale, and were all very good specimens of decoration and potting.

M. Deck, Paris.—Of all the exhibitors of fayence, M. Deck has done most for the advance of real art. His stand was the admiration of all who made a careful study of it, and every praise must be given to him for his encouragement of art, and for the beautiful results of his labour. I was pleased to see the names of the artists who had been employed on the work shown, hung upon the side of the stall. When shall we see that done in England? The vases exhibited were not too large, so that the eye could take in all the details of the decoration with ease. The most attractive were several large round plaques, about 2 ft. across, painted with large female heads, and other decorations. I saw one of them was bought by an English manufacturer. The price paid was £200. Here is an example of art workmanship! This dish, which realized such a large amount, could be made and sold by the gentleman who bought it, for about two shillings, and the artist with his labour has made it worth £200! The real alchemist must be the artist, for he seems to have the true philosopher's stone. I am glad the dish is coming to England, and pleased at this instance of an English employer having such a love of art. There is a pair of cylinder-shaped spills, on which birds are painted; the drawing of the birds is in a superior style. I have not seen anything to surpass it. As far as I can judge the colour and the glaze is all one. I would call it coloured enamels, with a powerful flux in it to form the glaze. The colours are different from the English majolica; the glaze of which is transparent, and shows the colour; but in this case the colours look more opaque and solid, while the surface carries a good glaze. The method of work seems to be laying the ground colour of the design first, then taking away the parts to form the design, and filling in with the colours wanted. The colours in some examples were raised up as high as three-sixteenths of an inch, and the white grounds laid upon some of the pieces looked like glazed porcelain, from the purity of the white. There are two plates painted with swallows resting on a telegraph wire; they have a comical appearance, and they look very happy together. There is a vase with Persian ornaments very finely traced in black upon it with a pencil, in low relief, and then covered with a turquoise green glaze; it had flown very equally indeed, and showed the tracing under. It had a charm of its own I shall never forget.

England.

Messrs. Copeland, Stoke-on-Trent.—This well-known manufactory has made itself a name at all the Exhibitions for first-class art and decoration. In statuary porcelain it led the way in the production of Parian as a new development of the pottery art, and the statuary still produced by this house is such that it will hold its own against all competitors. There are two busts of females shown, and the tone of the material and the way they are manufactured cannot be equalled by anything shown in the Exhibition in that line. They did not look as if they had been through a fire and were once in a liquid state, and they looked very solid and compact in texture. A large vase made in china with Cupids supporting it for a foot, is a fine specimen of china potting; it is decorated with flower painting boldly treated. I think I have seen this artist to better advantage in some of his other productions. There are two pairs of vases with an egg-shaped body, very good in form, shown with different handles (that lying flat upon the line is the most suitable), and the flowers are painted upon them in such delicate tones of colour that they seem to be reflected lights. There are several vases modelled and decorated in the Japanese style, of which Messrs. Copeland's artists seem to have their own treatment, not making a slavish copy of a vase from Japan, but using the Japanese style for the realizing of their own ideas. A large, flat, oval vase, with the dragon upon the neck, raised birds and flowers on the body, and the sides perforated, is a good specimen of the designer, and shows that he fully understands the style. There is a dessert set designed in the Chinese style, painted in the centre with birds and flowers, and the design is good and true to the style. A dessert set in china, with Parian figures for supports to the comports, is good, showing the combination of the two materials. A large vase, with panels upon the pedestal, and having tinted celadon ground; the painting of the flowers is beautiful, and the treatment of the serpents on the handles very good. Toilet ware in earthern is shown with sound decoration upon it, of which the eye will not tire; it is suitable to the requirements of all households in price and taste. The majolica shown by them is so good that I cannot make any comparison between them and those of the other good makers in England, to which it is so near in excellence.

The Royal Porcelain Company, Worcester.—These exhibits are from the well-known manufactory at Worcester, which earned itself a name before most of the present manufactories were in existence. As regards its productions in high art, a comparison of its present exhibits with those it displayed in the Exhibition of 1851 would show that they have made great progress and advance in the past twenty years, and I think they have fairly earned themselves a name for several specialities which they have made almost their own. In this Exhibition they show a fresh application of another style of art to the potter's list, in what they call "Japanese ivories." It seems to be the impression of many that they have been copying the Japanese porcelain in their productions, but in all the Japanese exhibits—and they show largely here—I have not seen anything that would at all suggest the designs for these specimens. The artists who designed and decorated them seem to have thoroughly mastered the style, and imparted to their designs that subtle feeling for art which the Eastern nations seem to alone possess. That they intended to be well represented is proved by their exhibiting nearly a hundred different articles. The designer has taken a Japanese form, and on it modelled in low relief the decoration, the modelling being done with the greatest care, to preserve its keen, fine lines. All the ware was very carefully made by the potter, for if it had not had that care bestowed upon all its details in every

process, it would be anything but what it was intended to be. The colouring of the relief is done with great distinctness ; the colours are more opaque than those ordinarily used, and almost all the plain surfaces are covered with the tint of ivory, with a good tone, and almost the texture. Some of the feet and supports are coloured to look like bronze and other metals, and all that sharpness of outline which the metal shows is well preserved in these examples—one could hardly believe it was not metal, instead of porcelain—which shows that a great deal of care and labour must have been expended upon the work. I can only mention a few of the things that struck me as showing good potting as well as good design and decoration. A pair of tusk-shaped vases with the frog story done in bronze and colours, and the same line vase with gilt storks, perforated. I think the perforated ones realized the ivory look as well as anything shown. A pair of pilgrim bottles with gold ground, and pottery subjects done in bronze upon the surface, were excellent. There are a set of vases with the decoration in relief, to illustrate the manufacture of pottery as carried on in China. The figures have a quaint, comical appearance, especially the thrower on the wheel, and one almost wishes to form his acquaintance as a brother in the potting art. A pair of cylinder-shape vases with ivory ground, bronzed and gilt, with coloured birds, and a large plateau pierced, on which are subjects in coloured bronze ; also a pair of figures of a Japanese lady and gentleman, of which all the details of the fine modelling are well preserved, both in the making and in the rich decoration of the garments, which is done in colour well kept in subjection to the general contour ot the figure. Altogether, it is a real treat to look at the skill and fancy displayed in the production of these "Japanese ivories."

Messrs. Wedgwood, Etruria, Stoke-on-Trent.—The coloured jasper ware shown by this house has great charms for potters—charms that a dilettante can never know, because he does not understand the technical difficulties to be overcome in the production of it ; besides the articles and the decoration of it are wholly done by the potters, and all its effects are the results of one firing, which is very different from the manner of producing high-class china, it having to depend for its decoration upon so many and different degrees of fire. Most of the coloured jasper shown, I think, looks brighter than the old examples in the museums. I do not see many shapes of vase, &c., shown, but what I have often seen before. There are two vases, with white grounds and coloured festoons upon them, which have a good effect ; but with the command of such wonderful bodies and colours, it is to be hoped that some fresh application of them, beyond the reproduction of the old shapes, &c., will be attempted. The larger vases shown are fine pieces of potting, and equal to any of the old. I saw a reproduction of the speckled, or mottled vase, at Kensington Museum, but I do not think the effect is obtained in the same manner as in this copy. A large table top, shown in the Henri Deux ware, is a new manufacture of this house, and is a fine specimen of that class of pottery, showing good art in the treatment of the difficult and intricate inlaying of the fine lines of colour composing the decoration ; it reflects great credit upon all who were engaged upon it. Upon the table is a set of chess-men, supposed to be modelled by Flaxman, which gives great interest to them from the high place he occupied in English art, and the connection in early life which he had with Josiah Wedgwood, and the improvement of English ware.

Messrs. Minton, Stoke-upon-Trent.—The magnificent show of ceramics exhibited by this house certainly surpasses anything shown by an English house in any exhibition. From the Exhibition of 1851 to the present, there has been that steady progress shown in the development of all their different classes of production to which England is indebted, in a large degree, for the high position she holds in the potting art and trade. Artists from all countries have always been encouraged, and there has not been that neglect of the native artist shown which is often the case. The results of this liberal patronage of art are well illustrated upon the stand in this Exhibition, and show the experience and knowledge of our twenty years of progress. It is the admiration of all the English who have seen it, and who know the excellent productions of this firm, and is a great surprise and wonder to foreigners. One hardly knows where to begin to note the most striking among so many praiseworthy productions. There is a specimen of the Henri Deux ware, a barometer and clock stand, about two feet long, to hang upon a wall. I do not know whether it is a copy of an original one, but it is a fine production, showing a vast amount of the minute and delicate lines of inlaying in colour ; one could hardly expect that a private manufacturer would undertake such a piece of work with any hope of profit, the labour bestowed upon it being so great ; I am glad to see it is sold to a real patron of English art. A candlestick, copy of the one in the Kensington Museum in the Henri Deux is shown ; I should like to see the two together, for the difference is so small that I do not think it could be detected. Two large vases, with blue *du roi* grounds upon them, and panels of painting on each side—one a landscape, the other a figure subject ; the artists who painted these show what Englishmen can do if they are properly trained and encouraged in art. For good sound painting, without any tricks of art, they are not surpassed by anything shown in the Exhibition. Two large vases, blue grounds, on which are storks and flowers, and bronze on the feet, are very fine in conception, and in all the details of manufacture ; but to name all the different classes of decoration shown, would require much more space than I can give.

General Conclusions.

As regards the Government manufactories, I do not think Dresden at all occupies the position it ought to. I am afraid they have increased the producing power of the works more for commercial purposes than for the development of the ceramic art, than which we expect something different from such works. The first place among these works exhibiting at Vienna is due to the Imperial Works of St. Petersburg. They show more advance, not in the production of anything new to the trade, but in the quality of the work shown. The decoration is better than the forms of the pieces, and there is not that elegance of outline which there might have been. However, they deserve credit for the great striving which they seem to have made to advance their reputation as Imperial Works. The capabilities of France in the manufacture of fine porcelain are not at all represented here, for the Limoges manufacturers do not show their fine potting, which was the admiration of all who saw it at the 1862 Exhibition.

The Austrian and German porcelain does not come up to my expectations, which were based upon the advantages they possess of technical and scientific education. I do not see any advance made by either Sweden or Denmark on former Exhibitions. Spain we must leave out for the present, but I am glad to see Portugal makes a start in porcelain manufactures. Italy I do not think has made much progress in bringing out anything to add to the list of new styles of production, but what they do make is kept up to its previous excellence.

If the Japanese still go on in the porcelain manufacture, as shown at Vienna, real Japanese art will only be found in the museums of Europe.

In my progress through the Exhibition, according to the arrangements, I began with the Eastern nations ; and after looking at the foreign exhibits of pottery, I was much impressed with the general excellence of English ware, all the forms, with few exceptions, being very good in design, and the decoration free from all pretence and bad taste. One did not see here good forms and decoration side by side with bad. The work looks honest, with art principles ruling it, and not the chance production of an individual trained in one part of the process, while the other parts are left to chance, but the ruling head directing and controlling the articles both in form and decoration.

I have no fear at all for the future of the potting trade of England, if our rising workmen will only submit themselves to be properly trained in art, and take all the advantages they can of technical and scientific education. With the magnificent collection of ceramics at South Kensington, to show the success of past productions, we ought to be ever on the move, endeavouring to gain a still higher position in art, and not forget that this Exhibition has shown foreign makers where they are deficient, and that every effort will be made by them to profit by its teaching. I know the Germans are quite aware of their position in this Exhibition, and that every encouragement will be given them by their country to enable them to compete in the markets of the world.

Stationary Engines.

In writing a report on the Stationary Engines in the Vienna Exhibition of 1873, care must be taken to look on every subject with an impartial eye, because this is the first occasion our foreign brethren have made a show, in any exhibition, at all approaching us, and that, although we have had to scheme and invent in the first place, which they have only followed, it is clear that they have the perseverance to emulate us, and are determined to equal us in quality and design. The stationary engines form a very great feature in the colossal hall, specially set apart for motive machinery, which is nearly three-quarters of a mile long. Different nations of Europe compete with each other in the production of various classes of engines, and it is only surprising that our large manufacturers should have overlooked the fact of the necessity of sending specimens to an

Exhibition in the midst of a people who are anxious to make themselves known in the engineering world. I conversed with several Englishmen in Vienna (one or two holding high official appointments), and the answer they gave me about the absence of English manufacture was not at all satisfactory. One said "the expense" was too great, and the advantages ultimately gained did not compensate for the outlay. Another said that if we exhibited our goods it was only for them to copy. My answer to both was, that while we were neglecting the time and opportunity, our foreign brethren were showing to the world that they could manufacture articles as good as ours, if not so cheap at first, and that there were other places where they could supply their requirements without having to come to England. And again, with respect to the finish of exhibition work, it is well known that most firms spend a good deal of time in getting up and finishing specimens of their manufacture for exhibition, to make them look as well as possible. When I remarked how well certain machines were finished, I was met with the reply, that it was quite unnecessary and useless, and that it was not intended to put so fine a finish on such work for ordinary use. This clearly shows that they can do their work well—in some cases quite equal to—if not superior to ours.

In looking for stationary engines to report on, I found all the nations of Eastern Europe represented with the exception of Turkey and Greece. The greatest number are from Germany and Austria, from the fact, I suppose, that these countries are nearest the Exhibition.

The Continental exhibitors have evidently looked forward to the Exhibition, and have attached great importance to it. I gather this from the fact that they have spared no expense, though some of the engines are of such large dimensions that one would have thought it unnecessary to lay out money in exhibiting them. One firm, the celebrated Schneider, of Creusot, has sent a 12-wheel locomotive, and, amongst other things, a compound condensing inverted-cylinder engine, elaborately got up, with all the polished work electro-plated. A New York firm exhibits a small inverted-cylinder engine, not more than 3 feet 6 inches high, and all the wrought-iron work in this is electro-plated. Danck and Co., of Prague, originally Danck and Co., in Prague, Danck and Co., in Aussiz, and Breitfield and Evans, in Prague, now formed into a joint-stock company, have exhibited in their pavilion amongst other things a large horizontal rolling-mill engine of colossal proportions. It is 1,000 horse-power, and has been sold for nearly £8,000 English money.

The Société Cockerill, of Seraing, have erected a gigantic blowing engine, with the blast cylinder overhead supported on four diagonal pillars, with two fly-wheels; and I was surprised to see it working. It was not quite steady, on account of the foundations not being as good as they should be, but it must have cost a considerable sum to set it to work at all. The design and workmanship are good.

Taking the engines altogether, I must say that the "Corliss" bears the palm; and although some of the valve gears look light with many parts, yet the eye becomes accustomed to them, and they are, no doubt, the engines we shall have to look to in the future. Most of them have the slides cylindrical, cast on the cylinder, cover and crank shaft pedestal. They are bored out at the same time the cylinder is turned, so that both are perfectly square with each other. The adjustment for wear is on the slide block and crosshead, and is effected by lock-nuts. Another feature in many cases is the polished cast-iron crank disc instead of wrought-iron crank. These look very well, and act also as small fly-wheels.

Schneider, of Creusot, sends an engine which, for design and finish, is second to none exhibited; but I cannot see any great advantage in electro-plating all the bright work. It certainly gives it the appearance of silver, but it hides any defects. Bede and Parçot, of Verviers, show an engine of the Corliss class, which is excellent. The valve gear is not worked by an eccentric, but by a horizontal shaft worked from the fly shaft, and a vertical shaft with cams does its work very well. The great advantage of the upright shaft and cam is that the exhaust is entirely independent of the steam, and can be worked without any back pressure by setting the cam.

In the Swiss Department the Gebrüder Sulzers' engines are both excellent, of the Corliss frame class. The large one has vertical circular valves, worked by a shaft driven off the fly-shaft, and two small eccentrics keyed on it, which are attached to the valve levers. The small engine is well arranged; the Corliss frame is strong and light, and the slide and expansion valves are regulated by the governor. Provision for working the air-pump, which is also well arranged, is very simple and good. This engine is of good design, and upon it engines from the smallest to any size may be made.

Polluk, of Augsburg, shows an engine of the Corliss class, exactly the same as Hicks', of Bolton. Design and workmanship excellent. The Augsburg Maschinenfabrik exhibit an engine of the Corliss class, with circular vertical valves on top, and exhaust in bottom. The air-pump is placed underneath front of cylinder, and is worked by eccentric on fly shaft. Design and workmanship excellent.

G. Sigl, Vienna and Berlin, has sent a pair of horizontal engines on the old principle, with the exception of the crosshead, with the bottom part in the shape of an inverted T. The expansion is also new, consisting of a rod which at one end is attached to the expansion lever by means of a pin with a square hole in. The pump is worked by a small double crank connected to crank pin, and fits in a pedestal.

Another firm, of Prague, formerly Ruston and Co., amongst other things, exhibit a winding engine with steam brake. The engine is a good strong one, and the arrangements for starting, reversing, and applying the steam brake, are very complete. The brake can either be worked by steam or hand, and the method of constructing the winding drum is very good. The boss on fly-shaft is cast-iron, with recesses in for double angle-irons, which project, and at the ends are joined by other angles, which are riveted. The arrangement of steam brake is also good, and the effect very powerful. The telegraph is a very useful addition, as it shows the engineman the exact position of the rope, ascending or descending. They also exhibit an horizontal engine of the Corliss class, with horizontal air-pump underneath, worked by a cast-iron bell-crank lever off crank-pin. Workmanship and design very good.

I will now give a summary of what I saw, as a comparison of foreign work with our own.

After a careful examination I find that foreign castings, as a whole, are clean and well done. The brass work is very creditable, the rough castings, as specimens, being clean; and particular care has been taken in finishing the work.

In the smithy department the work was, in some cases, neatly and artistically done, especially in the black work of locomotives, viz., brake gear, springs, coupling chains, and links, and other parts chiefly painted, which were good specimens of ordinary smith-work.

In the forge department are various kinds, such as connecting rods, uses, shafts, cranks, carriage wheels, finished and in pieces, tires, and the heavier portions of work, all of which show that they have extensive knowledge of the use of blocks for the work they have in hand.

The turning work, generally, is fairly done, especially in the heavier work, such as cranks, shafts, connecting rods, boring cylinders, and slide bars. Some of the work is on such a large scale, that it is evident that manufacturers have had good tools from the quality of work done, but it is also evident that they can scarcely have had the advantages we have.

The fitting is carefully done, care being taken in setting out the work; the parts which come together are well-jointed, and especial pains have been taken in finishing the parts, which work can only be done by the file.

The machine work is also very carefully done, and the shaping of radius parts, cranks, &c., and the heavy planing, is also accurately finished.

It is generally admitted that foreign manufacture in this particular branch has made very rapid strides in the last few years; having far surpassed us in the same time, and that we have not made that advance which our great experience and the talent of our workmen warranted us in expecting that we should.

After careful consideration of the qualification and abilities of foreign workmen judged by their work, the conclusion I have come to is, that they are quite able to hold their own with us, and that their best skilled men are fit to be placed on the same footing as ours.

It cannot be denied that the days of monopoly by English manufacture are past, that we all stand on the same level, and that in the opening of new countries in future, the foreign manufacturers will compete with us for their share of work.

No doubt a great deal of our past success has been due, in the first instance, to the extraordinary cheapness of the raw material and fuel, but these for the last two years have completely turned round, having nearly doubled in price.

Another great drawback to us at the present time is the uneasiness existing between employers and employed, and which, if not satisfactorily adjusted, will lose this country numbers of our best men, whom we can ill afford to spare. Both sides ought to reflect on the importance of this question, and endeavour in future to work together for the same object, which is to maintain the good name we hitherto have had, and which there is no just reason we should not keep.

I have not been able to get much information respecting the

rate of wages paid on the Continent, but have obtained those of several countries from the men who were at the stands :—

England	Skilled men, 34s. per week of 54 hours.				No Sunday work.
France	,,	5fr. per day of	10	,,	,,
Belgium	,,	4fr. 50c. ,,	10	,,	,,
Switzerland	,,	6fr. ,,	10	,,	,,
Italy	,,	5fr. ,,	10	,,	,,
Sweden and Norway	,,	1 rix-dol. (3s.)	11	,,	,,
	First-class men, ⅓ dollar more. Food, &c., very cheap.				
Germany	Skilled men, 11th. 2ogr. per day of		11	hrs.	Sunday work.
Schleswig	,,	25gr. ,,	10	,,	No Sunday work.
Bohemia	,,	2fl. ,,	11	,,	,,
Hungary	,,	3fl. ,,	11	,,	,,
Russia	,,	1½s.r. ,,	11½	,,	,,

(*To be continued.*)

THE FACTOR OF SAFETY IN ENGINEERING STRUCTURES.

By Richard H. Buel.[1]

COMPARATIVELY few engineers have the time or means to conduct thorough experiments on the strength of the materials which they are called upon to use; and in designing work they are generally obliged to accept the results of previous experiments. Fortunately, however, the ultimate strength of most of the materials in common use has been quite accurately determined, for the various strains to which they are subjected—and the engineer has only to decide how much of this ultimate strength he will use for a working load, or what factor of safety he will employ, the factor of safety being the quotient arising from dividing the ultimate strength by the working load.

In choosing this factor, there are several things to be considered—not only the kind of strains, whether tensile, compressive, transverse, torsional, or shearing, that will act upon the material—but also how these strains are to be applied, whether gradually, or all at once, after the manner of a blow. Other matters affecting the choice of a factor of safety will be mentioned further on. It is easy to see that the effect of a quiescent load upon a structure will be quite different from that of the same load suddenly applied. Suppose, for instance, that a force P is gradually applied to a bar, increasing its length by an amount S. The force commences to act with an intensity of nothing, increasing by slight degrees to P, so that the mean pressure exerted during the elongation is $P \div 2$, and the work of stretching the bar, called the work of resilience, may be represented by the expression $(P \times S) \div 2$. If this same force P is suddenly applied it will act during the elongation with a mean pressure P, twice as great as the former mean pressure—and if, in the first case, the bar is stretched up to its elastic limit, under the latter conditions a permanent set will be produced, or the bar will be broken. This is an experiment that can be performed by anyone, using a spiral spring, and applying a weight to it in the two ways previously mentioned. It would appear from this, that in the case of structures which are to be subjected to the action of impulsive forces, not more than one-half of the ultimate strength can be used for working load. It seems probable that forces do not generally act in this manner in ordinary structures. In the case of railway bridges and tracks, which are required to sustain a rolling load, both theory and experiment show that the force is more injurious to the material than if it were gradually applied, and that the effect is somewhere between that produced by quiescent and sudden loads, depending upon the speed of the moving train.

Mention has been made of the elastic limit, or the point at which a permanent set occurs, after the material is elongated, compressed, bent, or twisted, and it was formerly supposed that when a set was produced, the value of the material for resisting strains was destroyed. Subsequent experiments have shown, however, that a material may take a set, without having its strength impaired, and the limiting strain is that which does not increase the set, if repeatedly applied. The weight that will produce this limiting strain is called the proof strength of the material—and as this must never be exceeded in practice, it is evident that the engineer is interested in knowing the proof rather than the ultimate strength of the materials which he is to use. Experiments in regard to the ultimate strength of materials have been more extended than those relating to the proof loads, and, hence, the constants for the latter cannot be given with so much precision as for the breaking weight. From such experiments as have been made, however, many valuable conclusions have been derived, and it may be well to devote some little space to their consideration.

In regard to tensile strength, the following table gives average values in a few cases :—

Tensile strength in pounds per square inch of cross section.
(*Strain applied gradually.*)

Material.	Ultimate Strength.	Proof Strength.
Cast-iron	16,500	8,250
Wrought-iron (bar)	45,000	22,500
Wrought-iron (boiler plate)	50,000	25,000
Pittsburgh Steel (plate)	95,000	42,500
Bessemer Steel	99,000	44,500
Black Diamond Steel (bar)	120,700	60,350

These materials, when subjected to the action of sudden strains, give varying results—some of the strongest materials being broken by a blow which does not injure the weaker ones. This is because the elasticity of a material frequently varies inversely as its strength, so that the stronger grades are not so well able to resist shocks as inferior varieties. The following table, taken from Trautwine's "Engineer's Pocket Book," to which valuable work the writer is indebted for many of the figures used in this article, will illustrate this fact.

Ultimate tensile strength in pounds per square inch and elongation in inches, before breaking.[1]

Specimen.	Per cent. of Carbon.	Breaking Weight.	Elongation in inches.
No. 1	·33	68,100	1·37
No. 2	·43	76,160	1·37
No. 3	·48	84,000	1·25
No. 4	·53	95,200	1·12
No. 5	·58	92,960	0·81
No. 6	·63	100,800	1·80
No. 7	·74	101,920	0·69
No. 8	·84	123,200	1·12
No. 9	1·00	134,400	1·00
No. 10	1·25	154,560	0·62

It appears from the foregoing remarks that the proof strength of metals used for structures, in reference to tensile strains gradually applied, has an average value equal to one-half the breaking weight, this value varying with the quality of the material. As many structures are exposed to strains acting somewhat in the nature of blows, not more than half the proof strength should be used as a working load. This fact is recognized by reputable engineers, who, in designing iron bridges, proportion the parts composed of wrought iron to bear a maximum tensile strain of from ten to twelve thousand pounds per square inch, and many consider that 8,000 pounds per square inch should be the extreme limit for the working load, on account of some other facts in regard to the strength of materials, which will be briefly considered.

The constants used by the engineer in his calculations are generally obtained by experiments upon small pieces of the materials. Now, it is well known that increase of strength does not always follow in direct proportion to increase of size. A large wooden beam, for instance, is more liable than a small one to be weakened by knots and other imperfections, and on account of the difficulty of securing equal cooling in making large castings, large cast-iron beams are frequently weaker in proportion to their size than small ones. It may be mentioned, in this connection, that Mr. Hodkinson found it necessary to make corrections in his rules for the strength of cast-iron pillars, after experimenting upon pillars of larger size.

Structures exposed to the weather are subjected to great variations of temperature, and when metals are cooled, although they resist quiescent loads quite as well as before, they are more easily injured by sudden shocks, such as are caused by rolling loads.

It is commonly recommended in treatises on the strength of materials, that from one-fourth to one-eighth of the ultimate strength of the material should be taken for a working load, but it would seem that the proof strength is really the limit to be considered. This can be illustrated again by a reference to the resistance of materials to transverse strain. The application of a load to a beam causes a deflection, and, if the proof load is exceeded, the material can no longer be regarded as safe. From the results of experiments on the deflection of beams, the following table is compiled :—

[1] By the courtesy of the Author we have received an early copy of this contribution, originally appearing in the New York "Iron Age."

[1] The specimens tested were steel bars of different grades, made from pure Swedish iron, and each bar was turned down to a diameter of 1 in., for a length of 14 in.

Average values of ultimate and proof strength in pounds, of beams one inch square and one foot in length between supports, when supported at both ends and loaded in the middle, the load being gradually applied.

Material.	Ultimate Strength.	Proof Load.
Cast-iron	2,000	800
Wrought-iron	2,400	1,000
Steel	6,000	5,000
White pine	450	150
Oak	600	200

These, it must be remembered, are average values, the same variations being observed in different qualities of the same material when suddenly strained, as previously remarked in the case of tensile strength, so that really the proof strength is the only safe figure from which the engineer can deduce the factor of safety. Average values of these factors, so that the load shall equal the proof strength, are given below :—

Material.	Factor of Safety. Load gradually applied.	Impulsive Load.
Cast-iron	2·5	5·0
Wrought-iron	2·4	4·8
Steel	1·2	2·4
White pine	3·0	6·0
Oak	3·0	6·0

It will be seen that the proof loads vary with the different materials, whence the factors of safety for the working loads will also vary, if they are taken with reference to the ultimate strength of the materials, while, if calculated with respect to the proof loads, they will be the same in every case. This will be rendered clear by the accompanying table, which also contains other matters of interest :—

Rectangular beams, loaded so that the deflection shall not exceed one-third of that caused by the proof load.

Material.	Distribution of Load.	Break'g Weight.	Proof Load.	Deflection under Proof Load.	Deflection under the same Load.	Assumed safe Deflection.	Load that will produce Safe Deflection.	Factor of Safety. In reference to ultimate Strength.	Factor of Safety. In reference to proof Strength.
Wrought Iron.	Supported at both ends, and loaded in the middle	W	0·417 W	D	d	0·333 D	0·138 W	7·2	3
	Supported at both ends, and uniformly loaded	2 W	0·833 W	1·25 D	0·625 d	0·417 D	0·278 W		
	Fixed at one end, and uniformly loaded	0·5 W	0·208 W	3 D	6 d	D	0·069 W		
	Fixed at one end, and loaded at the other	0·25 W	0·104 W	4 D	16 d	1·333 D	0·034 W		
Cast Iron.	Supported at both ends, and loaded in the middle	W′	0·4 W′	D′	d′	0·333 D′	0·133 W′	7·5	3
	Supported at both ends, and uniformly loaded	2 W′	0·8 W′	1·25 D′	0·625 d′	0·417 D′	0·267 W′		
	Fixed at one end, and uniformly loaded	0·5 W′	0·2 W′	3 D′	6 d′	D′	0·067 W′		
	Fixed at one end, and loaded at the other	0·25 W′	0·1 W′	4 D′	16 d′	1·333 D′	0·033 W′		
Timber.	Supported at both ends, and loaded in the middle	W″	0·333 W″	D″	d″	0·333 D″	0·111 W″	9	3
	Supported at both ends, and uniformly loaded	2 W″	0·667 W″	1·25 D″	0·625 d″	0·417 D″	0·222 W″		
	Fixed at one end, and uniformly loaded	0·5 W″	0·167 W″	3 D″	6 d″	D″	0·056 W″		
	Fixed at one end, and loaded at the other	0·25 W″	0·083 W″	4 D″	16 d″	1·333 D″	0·028 W″		

The breaking weights, W, W′, W″, in the above table, are to be calculated for any particular case by the formulas in general use ; using for constants the figures given in tables of the transverse strength of materials. The deflections, D, D′, D″, can be calculated or determined experimentally for a beam supported at both ends and loaded in the middle, when the deflections for other distribution of the load are given at once from the table. The deflections, *d*, *d′*, *d″*, are determined in the same way for any load less than the proof, and the table shows the corresponding deflections when this same load is differently applied. By observing the relations given in the table, the load required to produce any deflections within that produced by the proof load, can readily be calculated. The safe load assumed in the table is one that is approved by experiment, though somewhat smaller than is often allowed. The following table is calculated for this load, or with a factor of safety of one-third the proof strength :—

Safe Loads, in pounds, for rectangular beams whose length between supports is l *feet ; breadth,* b *inches ; depth,* d *inches ; and unsupported weight of the beam,* B *pounds.*

Distribution of Load.	Wrought Iron.	Cast Iron.	White Pine.	Oak.
Supported at both ends, and loaded in the middle	$333 \times \frac{b \times d^2}{l} - \frac{B}{2}$	$267 \times \frac{b \times d^2}{l} - \frac{B}{2}$	$50 \times \frac{b \times d^2}{l} - \frac{B}{2}$	$67 \times \frac{b \times d^2}{l} - \frac{B}{2}$
Supported at both ends, and uniformly loaded	$667 \times \frac{b \times d^2}{l} - B$	$533 \times \frac{b \times d^2}{l} - B$	$100 \times \frac{b \times d^2}{l} - B$	$133 \times \frac{b \times d^2}{l} - B$
Fixed at one end, and uniformly loaded	$167 \times \frac{b \times d^2}{l} - B$	$133 \times \frac{b \times d^2}{l} - B$	$25 \times \frac{b \times d^2}{l} - B$	$33 \times \frac{b \times d^2}{l} - B$
Fixed at one end, and loaded at the other	$83 \times \frac{b \times d^2}{l} - \frac{B}{2}$	$67 \times \frac{b \times d^2}{l} - \frac{B}{2}$	$13 \times \frac{b \times d^2}{l} - \frac{B}{2}$	$17 \times \frac{b \times d^2}{l} - \frac{B}{2}$

Before concluding, a few remarks will be made about the factor of safety for the iron used in the construction of steam boilers. The most reliable authorities on this subject state that a factor of six in relation to ultimate strength is the least allowable, while it is more desirable to use a factor of eight. The experiments of Sir William Fairbairn have shown that the strength of a single riveted joint has but 56 per cent. of the strength of the sheet, and that a double riveted joint, properly constructed, has 70 per cent. The average tensile strength of boiler plate, as given above, is 50,000 pounds per square inch, and much is used that falls below this figure. This will give the ultimate strength of the riveted joint, as follows :—

Double riveted	35,000
Single	28,000

Hence, the greatest allowable working load should be :—

Double riveted	5,833
Single	4,667

And the best authorities recommend that the working load should not exceed :—

In boilers with double riveted joints	4,375
„ single „ „	3,500

A committee appointed by the Franklin Institute, of Philadelphia, to determine a safe value for the strain upon steam boilers, have recently reported to that body. They assume the ultimate tensile strength of a single riveted joint to be 34,000 pounds per square inch, and recommend that 6,000 pounds per square inch be taken for the working strain. If the foregoing data are correct, this allows a factor of safety of 28,000 ÷ 6,000 = 4·67, far below what is generally assumed to be a safe limit. It may well be doubted whether this influential body has not committed a grave error, in pronouncing this opinion.

The American Engineer and Inventor:

SELECT ABSTRACTS OF PATENTS RECENTLY GRANTED IN THE UNITED STATES.

[*For information concerning this department see the notice on the wrapper below the Contents of the Number.*]

686. Improved Nut Lock.

This invention is an edge-perforated washer, connected and turning only with the bolt, and projecting laterally beyond the nut or nuts, combined with pins to lock the latter.

687. Improved Fastener for Meeting Rails of Sashes.

This invention relates to the ordinary sash fastener which prevents the window from being opened, and consists in a hinged plate, combined with the sash fastener, to turn down over the opening between the sashes whenever they are locked. This is the most perfect sash fastener that has come before this office for some time.

688. Improved Car Coupling.

This invention consists of a drawbar or coupling box, with side parts hinged to the rear part, and connected firmly by a hook frame, which is detached by the coupling link in case of accident, and produces the giving way of the sides and the uncoupling of the link. The coupling pin is hinged to a frame, with lever, latch, and gate, of which the latter is struck by the link, carrying the pin down for coupling. For uncoupling the lever is raised which detaches the link.

689. Improved Plough.

This invention is a plough adapted for ready adjustment to run at different depths in the soil, by changing the angle or inclination of the standard and shoe or shovel to the beam, also of the share or shovel to the standard.

690. Improved Vehicle.

The wheels and frames bear against superposed springs and are placed within the sides of the carriage body. They are incased upon the inner side, no part of the wheels being in sight except the part that projects beneath the body of the carriage. The forward end of the carriage is supported upon a single small wheel, or two small wheels placed close together, and the ends of the journal of which rest upon a frame. To the frame is attached a spindle which enters a socket attached to the front platform of the car body, and in which is placed a coiled spring. To the forward end of the frame is jointed the tongue, and to its rear end are pivoted two guide rollers, between which passes the semicircular guide rod, the ends of which are attached to the forward end of the carriage body. In the upper forward part of the carriage body is a box containing an endless strip passing over rollers. The driver can readily adjust this strip; and as suitable names are printed upon it, he can thus enable the passengers to know what street will be crossed next.

691. Improved Wood Sawing Machine.

This invention consists of a saw frame of a power sawing machine, suspended by a couple of swing bars, one of which is connected to an arm which is capable of rising and falling, and is provided with a lever by which the saw is lifted up and let down as required in the progress of the work. The lever is arranged to be manipulated by the operator while in the position for turning the crank. The invention also consists of a saw bench for receiving the piece cut off, arranged on a pivot and connected by an arm and rod with a hand lever, so that the attendant can throw off the piece by a quick movement of the lever while standing at the place for attending to the driving gear and the saw-adjusting lever.

692. Machine for Removing Snow and Ice from Roadways.

This invention consists of apparatus in a portable machine adapted to run along the roadway, so contrived that it will sprinkle the surface of the roadway with hydrocarbon substances, at the same time converting some of the said substances into vapour and burning it in a space above, and causing the flame to impinge upon the surface and burn the portion sprinkled thereon directly in contact with the snow and ice.

693. Improved Hominy Mill.

The corn is admitted to the mill through a hopper, and is immediately subjected to the action of the teeth of a rapidly revolving cylinder, whereby the hulls and hearts of the kernels are knocked off and separated from the corn. The kernels of corn are also broken more or less, and dust and meal are made from the fragments, which are thrown by centrifugal force of the revolving cylinder through the perforations of the casing, leaving the hominy clean and free from dust.

694. Improved Subsoil Plough.

This invention is a subsoil plough so constructed as to run easily and steadily through the hardest soil, and loosen it thoroughly. The standard curves forward as it projects downward, and is made thin with its forward edge sharp, to enable it to pass readily through the ground. The base of the cutter is made with a bar extending to the rearward. Upon the under side of the bar is formed a notch or recess, into which is fitted the convex upper side of the shovel, which is securely bolted to said bar. With this construction, as the plough is drawn through the ground the shovel loosens the soil and breaks it up, leaving it light and loose without removing it from its place.

695. Improved Folding Pail.

This invention consists of a folding pail composed of an india-rubber or other suitable elastic tube for the body, a metal hoop or band at the top and bottom, a wood, rubber, or other suitable bottom, and brace rods connecting the top and bottom hoops. These rods are jointed to the hoops and jointed together, so that when the pail is to be used, they can be extended to extend the tube, and will hold it in the extended condition. They can also be folded down so as to fold the tube into a small, flat, compact package for convenience in carrying it in a waggon for use in watering horses and the like. The brace rods are arranged on the outside of the tube, and connected to the upper hoop by the same connection by which the bail is attached, and so suspend the weight directly from the bail.

696. Improved Furnace for Desulphurizing Ores.

This invention relates to a new construction of the vertical shaft furnace for desulphurizing, calcining, and drying, the same ores or other substances when in a fine or powdered state. Vertical series of inclined plates form troughs from the bottom of the furnace to the top. When the inclined plate or trough at the bottom of the column is empty, the ore of the trough next above it flows down into it until it is filled, and this process takes place along the whole column of inclined plates or troughs to the top of the furnace, where the reservoir is placed. The removal of the ore from the bottom trough causes a simultaneous movement of the ore from each trough above to the one below, and a sliding of the ore takes place along the whole column to the top reservoir of the furnace, and from the reservoir into the uppermost trough, and this movement is arrested or made continuous, just as the bottom trough is allowed to remain full or be emptied. The inclined plates are also so constructed as to allow the passage of the ascending heated gases under and next to the column of ore, where the heat is applied most effectually in contact with the ore in the trough. Finally, the invention consists in a modification of the position of the plates with the use of conduits or pockets along the inner walls of the furnace for conveying the gases, from one horizontal passage to the other, around and over the several layers of ore.

697. Improved Fire Indicator and Alarm.

This invention consists of a little cage of wire or perforated sheet metal containing a card of matches, or other easily ignitible substance, arranged under a string holding a trip lever, with which a wire is connected. The wire extends to the indicator and alarm in the office or occupied room of the building, and is attached to a wheel, which when let free by the burning of the string in the aforesaid cage is turned by a spring, and caused to trip the mechanism of an alarm apparatus, and at the same time present to the sight hole through the case the number of the room in which the cage is fired. Any number of the detectors can be arranged in a room in different points, and connected with the indicator and alarm.

698. Improved Walk Edger.

The object of this invention is to provide convenient means for edging walks in yards and lawns, cutting turf straight and square for that or other purposes; and it consists in an axle, at one end of which is an ordinary wheel which runs upon the surface of the walk. At the other end is a drum which runs upon the turf. A circular cutter made of thin steel is attached to the side of the drum, and a plough-share follows the cutter and reverses the sod as the latter is cut. A gauge is attached to the plough beam for regulating the depth of the plough.

699. Improved Track Clearer.

This invention consists in two wheels arranged in front of the cow-catcher of a locomotive and in a plane perpendicular to the direction of the track. By suitable gearing, these are connected with the forward axle, so that the wheels are swiftly rotated, causing radial wings or shovels attached thereto to throw and blow the snow from the track, and thus work their way rapidly through the snow even should it be greatly drifted.

700. Improved Hoop Lock.

The object of this invention is to provide a way for fastening or tying the ends of wooden hoops together for barrels, tubs, and other cooper work, and for other purposes, and it consists in a metallic tie having two sockets connected together, in which sockets the ends of the hoops are wedged.

701. Improved Cherry Stoner.

By suitable construction, as punches descend upon the cherries in tapering holes, the stones are punched out of the fruit and through the holes, and fall into a dish placed beneath the said holes. As the punches ascend they carry the fruit with them up to a plate having holes in it, through which the punches pass but not the fruit, so that the latter is pushed or stripped from the said punches. As the punches ascend the pan moves back so as to pass beneath the punches and receive the fruit as it falls from the plate. The fruit slides down the pan into a dish placed beneath the lower end of said pan. The descent of the cherries in the pan is regulated with one hand, while the crank is turned with the other.

702. Improved Cotton Gin.

This invention is an improvement in the class of gins having auxiliary bars or fingers applied to the ordinary bars or fingers between which the saws revolve; and the invention consists in the arrangement of short secondary fingers so as to be readily attached and detached, and to be shifted or moved toward the saws from time to time, as they wear smooth at the corners, thus exposing new and sharp edges.

703. Improved Ticket and Delivery Holder.

This invention relates to fare boxes, and consists in providing a lock case with sliding drawers which are partitioned off, inclined, and caused to allow the exit of the tickets one by one.

704. Improved Door Spring.

There is a casing of cast-iron which contains the springs and jaws. The ends of the jaws clasp a central stud and a transverse plate on top of the stud which holds the jaws in place. The lower end of a shaft turns on a pivot on the bottom of the case, and has a roller on the end of an arm. The end of the shaft extends up above the top plate, and is rigidly attached to a lever. The jaws are forced toward each other by a circular spring which exerts a constant pressure. The lower end of the door is rigidly connected with the lever. When the door is swung open, it carries the lever and arm with its friction roll, which spreads the jaws one from the other. The jaw becomes a lever of constantly increasing power, the fulcrum being the stud and the spring the resisting point. When the door has made a quarter circle or is wide open, the roller will be carried to near the outer end of the jaw, and the arm will be parallel with the door. In this position the spring will bear directly against the axis, and the door will remain stationary. Should the door be left at any intermediate point, it would be closed by the spring. By means of this apparatus the ordinary butt hinges are dispensed with. The door is held open when desired, and is self-closing at all times when not wide open.

705. Improved Hand Corn Planter.

A cap is placed upon the lower part of the seed box, where it is secured in place by two spring catches which pass up on the opposite sides of the lower part of the hopper and catch in notches formed in the sides. The lower part of the cap is formed by two parallel plates, one of which is stationary and the other pivoted. To the upper part of the pivoted plate is attached a hook which hooks upon a crank. Upon the crank shaft is formed an arm, to the outer end of which is pivoted the lower end of a connecting rod. With this arrangement the plates, which are pressed close together by the action of the spring, are forced into the soil, and the rear end of a lever is drawn upward or toward the handle. This movement operates the slide and drops the seed and plaster by spreading the plates apart. As the lever is released the spring moves the various parts of the machine back to their former position.

706. Improved Fertilizer Distributer.

This invention is a machine for opening a furrow and distributing guano in it preparatory to planting cotton or other seed, simple in construction, convenient in use, and reliable in operation. The invention consists in the shoe provided with a spout held in pivoted suspension bars, so as to allow the shoe to have a backward and forward movement. In the shoe is formed a hole, through which the guano escapes to the ground through the spout, which is designed to guide the guano into the furrow, and prevent it from being blown about by the wind. The rear part of the shoe is supported by a cord, so that the inclination of the shoe, and consequently the rapidity of discharge, may be increased and diminished by unwinding the cord from and winding it upon a knob. A wheel is placed directly in the rear of the conduction spout, and is made with a deep V-shaped groove in its face, and with a number of rods crossing said grooves near the periphery of the wheel. As the wheel revolves, each rod pushes the lower end of a spring forward, which end, as it escapes from said rod, springs back against the next rod, thus jarring the shoe, and insuring the constant and regular discharge of the guano. The amount of guano escaping from the hopper is also regulated by a slide. By suitable construction, by operating a lever, the lower part of the spring is thrown forward away from the rods of the wheel, to allow the shoe to stand still, and thus enable the distribution of guano to be stopped when desired.

707. Improved Door Check.

This invention consists of a pair of legs jointed together and to a slide on the door or gate, so as to be shoved down on the floor or ground, and at the same time extended from each other in both directions in which the gate or door swings, so that by bearing on the floor or entering the ground they will hold the door or gate from swinging. In the case of a door, the legs and slide will be arranged in a recess in the edge extending upward a suitable distance from the lower corner, so as to be worked up and down by hand, and will have a set screw to fasten it; but in a gate the legs, being similarly arranged in a recess on the end post of the gate frame, may be worked by a lever, with which buttons are arranged to hold it in the position for keeping the legs in the ground or out of it.

708. Propelling Canal Boats and other Vessels.

This invention consists in propeller wheels combined with close channels inclined downwardly from bow to stern, and receiving the water from the surface in front of

the boat and discharging it at the rear, whereby the surface waves from the front of the boat, that tend to cause the washing of the banks, are prevented.

709. Improved Hand Corn Planter.

The outer case of the corn planter is of oblong shape, and the remainder half prism, base upward. A vertically sliding plunger extends through the full length of case along the rear side of the same. The plunger has at its upper end a handle, and at its lower end a metallic piece with a sharp edge to enter the soil and carry the seed before it. On it there is a spring plate, placed diagonally to act with a cam movement on the teeth of a horizontal revolving seed cup disk. Above the latter another cam spring, diagonally placed in the contrary direction, completes the distributer. The corn chamber is arranged in the upper part of case. A vertical slide piece has an inclined end for the purpose of admitting a smaller quantity of corn to the revolving disk, and taking off the weight of the corn from the same, making thereby its motion easier and quicker. The revolving distributing disk is perforated by a certain number of holes of such size as to admit freely the seed or corn. A double row of vertical brushes is arranged to allow the seed to fill the holes to the rim, and to brush off the other seed to drop into the other holes when the same are approaching toward them by the revolving of the disk. By suitable adjustment the amount of seed passing to the distributer disk may be regulated. The seeds pass down as each hole discharges its contents into the lower part of the planter, dropping on an inclined band spring. The seed is then carried into the ground by the descending plunger end. The spring action of the band presses its end firmly against the plunger, so that no seed can escape. It serves, also, on the upward motion of plunger, as a scraper to clean the same from the adhering dirt. The depth to which the plunger is intended to penetrate the ground and deposit the seed can be adjusted as the different soils require it.

710. Improved Knife Cleaner and Polisher.

This invention consists in the improvement of knife cleaners by the introduction of a spring-pressed holder provided with a horizontally slotted top piece, and combined with a lever having a side pivot working in slot. By this improvement a knife drawn back and forth a few times not only comes out perfectly clean but beautifully polished.

711. Improved Car Axle Lubricator.

This invention relates to means for lubricating the parts of a car axle journal, whereby the surface of the flange and the body of journal are automatically provided with a graduated supply of oil or lubricating substance.

712. Improved Adjustable Bench Vice.

This invention is a bench jack for carpenters' and cabinet makers' use, for holding boards while being jointed. A bar is slotted to receive the jaw, and has notches to receive the pawl, by which the jaw is supported when adjusted. The jaw has ratchet teeth formed upon its upper side. The shank also passes through the frame, the forward end of which is so formed as to fit and slide upon ways formed upon the rear side of the ratchet bar. By suitable construction the shank of the jaw holds a piece in place in the frame, which forms a rest and also holds the frame in place upon the rear side of the ratchet bar. To the forward end of the piece is pivoted a pawl, which is so formed that its own weight may hold its lower or engaging end against the notched forward side of the bar. The pawl thus supports the rest, the frame, and the jaw in any position into which they may be adjusted, the said parts all moving together. There is also other mechanism which allows the jaw to be more accurately adjusted to the thickness of the board to be held. In using the device, the ratchet bar is secured to the bench at a proper distance from the vice, and the jaw is adjusted at the proper height to receive the board. The board is then arranged in place and the jaw pushed in against the side of the said board.

713. Improved Grain Hulling Machine.

This invention relates to a process for removing from grain its outer husk or bran, and it consists, first, in subjecting the grain after the ordinary cleaning to the action of water or steam, to soften the husk, then passing it between two roughened metallic surfaces, one revolving within the other.

714. Improved Boat Gripe and Crane Keeper.

This invention relates to the gripes and cranes used on board of a vessel for the purpose of handling the boats, and consists in combining a lever having clamp and hook chain with a single chuck to hold the boat in position on deck, and allow it to be easily detached, swung out, and let down into the water.

715. Improved Match Box.

The object of this invention is to provide safe and convenient receptacles for matches, connected with the gas-burner bracket; and it consists in the match safe combined with the bracket.

716. Improved Corn Planter.

By suitable arrangement a plate not only serves as a guide for the corn, but at the same time the alternating movement of a roller gives to the said plate an up and down movement, so that it may push out any dirt that may enter the interior of the standard. A stirrer passes through a hole in the side of the hopper, so that the stirrer may move back and forth in the hopper above the discharge opening, and thus keep the corn stirred up, so that it cannot clog and will pass out freely. The stirrer moves back and forth close to the upper side of the dropping roller, so as to operate as a cut off to prevent any more seed than enough to fill the dropping recesses from being carried out by said roller. Covering ploughs or wings, which are attached to the sides of the lower end of the standard, are formed to guide the soil into the furrow at the rear of said standard and cover the seed.

717. Improved Middlings Purifier.

On the top of a rectangular case, near one end, is a funnel-shaped receiver, which is to be placed directly under the floor on which the pile of middlings lies, the floor having a hole as large as the top of the funnel, or thereabout. In the opening of the funnel is a revolving cone feeder nearly filling the opening. This cone, which is adjustable vertically to open the passage more or less, is provided with grooves in the sides, which facilitate the feeding by scraping off the mass lying upon the cone regularly, and producing an even stream. It is revolved by gearing at the lower end, connected with the main driving shaft. Immediately under the cone is a flat shaking sieve hung by hooks at the upper end to the wall of the case, and at the lower end resting on the cams, which lift it and let it fall at each revolution. At the lower end the coarse matters escape, to be blown out of the case by the blast from the fan, but the finer portions fall through the sieve on the returning chute attached to the under side of the sieve, and descending toward the upper end of the next sieve below, on which it discharges. This sieve is like the one above, except it is a little finer. The coarse light matters from the lower sieve also escape off the end, and are blown out of the case. These are again separated into two grades by the plates and a passage which turn the heavier portions downward, while the lighter portions pass over and beyond.

718. Improved Rotary Engine.

The steam enters successively into two cylinders, both fast to the main shaft, and in each of which is a piston wheel. Each wheel has three pistons, so that two are always under steam pressure when the third one is taking steam. The pistons are of peculiar construction, being longitudinal sections of a cylinder with a circular head at each end, upon which are journals, to the latter of which a crank is attached. When the pistons reach the abutments, they are turned so as to fit into the cavities. As they leave the cavity, they are directly turned so that the broad and more flattened sides take steam, thus making the steam surface or area of the piston greater than the area of the cylinder. The steam is introduced into the first cylinder from below, the valve being operated by means of a lever, which is held in position by means of a spring lever and circle. The exhaust aperture opens from the second cylinder. The intermediate valves between cylinders are placed back of the abutments, and are operated by means of the ribs on the plates of the piston wheels. The ends of the valves project inward, and are triangular in cross section. As the wheels revolve, the end of the ribs strikes one of the angles, and turns the valve so that the ports admit and exhaust steam. It will be seen that the steam, after doing work, and consequently losing a portion of heat and pressure in the first cylinder, is exhausted into the second cylinder, where it acts upon the pistons in the same manner, doing more work, and parting with a large portion of its remaining heat and pressure.

719. Improved Fire Place.

A couple of side plates are set upright in a groove in a cast metal bed plate, said plates being curved to correspond with the said groove. They are arranged on opposite sides of the bed piece, to rest at the back against the partition wall, being about as wide as the thickness of the wall, and as high as the fire place is to be. They are fastened in the groove, at the lower end, by a flange. The fire grate is a round basket fitting the side plates, and mounted on a pivot so as to turn freely. It has a partition of fire-brick dividing it as high as the back plates, of which there is one for each room. The grate, together with its partition, can be turned so that one fire in one part of the grate will warm both rooms, or it can be turned half way around, and thus change the fire from one room to the other, which may be desirable when only a little heat is required for ventilating the rooms, or when the temperature is not very low.

720. Improved Nut Lock.

Four nuts are locked by this invention. This is the number of bolts usually employed for securing fish plates to rail joints. The end of the plate locks the first nut; the second nut is enclosed by a square hole in the plate; the third nut is locked by a lock plate; and the fourth nut by the end of the lock plate or by both. The end of the spring plate extends sufficiently far to form a spring, and is reduced in width, so that it passes through a slot or hole in the locking plate. By raising the end of the lock plate to a right angle, the third nut is unlocked and the spring plate can be removed without difficulty. The tension of the spring of the spring plate holds the locking plate in place.

721. Improved Button Hole Stitching Attachment for Sewing Machines.

This invention consists of apparatus mounted on a frame arranged to be attached to the head of a sewing machine, and connected to the needle bar to be operated. The device is arranged to cause a hook to pass down through the throat plate and engage the thread immediately after the shuttle has passed through the loop, draw it up through the button hole, and present it to a pusher, which, by a portion of said apparatus, is caused to carry the loop beyond the needle, and hold it until the needle goes down through it and completes the stitch.

722. Improved Clothes Wringer.

The journals of the rolls work in slots in the standards, and upon the journals of the upper roll are placed half bearings, upon which rest the ends of the curved spring, the middle part of which is attached to the top bar. To one journal of each roll is attached a gear wheel, the teeth of which mesh upon a circle of pins or cogs attached to the side of a disk or wheel attached to the other journals of the rolls. The gearing, thus constructed, gives greater capacity to the machine, or allows the rolls to work closer together or farther apart without binding or getting out of gear. Upon the edge of the gear wheel of the lower roll is formed an outwardly projecting flange, upon the inner surface of which are formed gear teeth, into which mesh the teeth of the small pinion wheel, attached to the crank shaft, which works in a long bearing in a bracket attached to the standard. This construction is claimed to give a greatly increased power to the wringer.

723. Improved Bird Cage.

This invention consists of a perch for bird cages, constructed in two parts, which are tongued and grooved together so as to form a very narrow crack along each side, such as insects and vermin, which infest birds, like to hide in, and so that the two parts of the perch can be readily taken apart to destroy the insects, when the perch is removed from the cage.

724. Improved Garden Cultivating Implement.

This invention is an improved implement for use of gardeners, nurserymen, &c., for cultivating various plants by hand. It includes a shovel or plough, rake, weed cutter, clod-breaking roller, and an adjustable transporting wheel. The plough is made double, one end being made small and the other large, so that one or the other end may be used, according as the work to be done may require. The forked shank of the rake is bolted to the standard. The blade of the weed cutter is made V-shaped, and is secured to the ends of the arms of the shank, which is in turn secured to the standard by the same bolt that secures the plough. The same means secure the roller by its shank. The function of the rake is to clear the surface of vines, weeds, &c., whose roots or stems may have been severed by the cutter. The roller is used by the weed cutter and rake, principally for the purpose of preventing the former entering the earth too far or sustaining too much of the weight of the frame of the implement. The shovel is detached when the weed cutter is used, or else turned so as to be crosswise of the standard. Similarly the weed cutter is detached when the shovel is used.

725. Improved Machine for Drawing Wire.

The apertures in the plates or dies are of successively decreasing diameters, the last being of the proper size for bringing the wire to the intended gauge, and the numbers of teeth in the pinions are so proportioned as to cause the pulleys and block to rotate at an increased surface speed in proportion to the attenuation of the wire. Motion being now communicated to the main shaft, the wire is drawn by the pulley successively through the different dies, the numbers of teeth in the pinions being, as explained, in such proportions as to enable the pulleys to take up the increasing length of wire. Instead of the pulleys being of the same diameter, arranged to be driven at different speeds as regards their revolutions, they might be of diameters increasing toward the block, in which case the series of bevel pinions might be furnished with equal numbers of teeth; further, instead of one pulley being used for each draw plate or die and the wire wound around such pulley, a series of small pulleys (say three) might be employed, the wire passing alternately under and over them, so as to provide sufficient surface for holding contact with the wire. The surface speeds of the pulleys and block will be required to be varied in practice for obvious reasons, such as when drawing wire of iron, steel, or brass; but the adjustment of the said pulleys and block, so as to provide a correct surface velocity will be simple to practical wire drawers.

726. Improved Door Spring.

A tube is pivoted to a bracket attached to the casing, and supported by a second bracket passing through a slot in its bottom and secured to the door. In the rear part of the tube is placed a coiled spring of sufficient strength to shut the door quickly and with a slam, if allowed to act freely. The forward end of the spring rests against a piston, which is attached to the end of the door bracket, so as to move back and forth through the tube. The piston is made of such a size as to slide freely through the tube, and to its forward end is attached a cupped packing, made of leather or other suitable material, and which moves freely through the tube as the piston moves toward the rear end of the said tube, and which, when the piston moves forward, serves as a valve to push the air forward, and thus cushion the piston upon compressed air, so as to check the door just before it closes, and thus prevent it from slamming. The air escapes through the forward end of the tube, where its escape is regulated by a grooved screw.

727. Improved Steam Engine.

Part of the boiler constitutes a wheel case, in which there is a wheel to which the steam is delivered to the boiler through a passage on one side of the vertical centre of the wheel, to give the steam that direction at starting by the lesser weight of the water on that side, due to the lesser height of the water column. There is another passage from the boiler to the other side of the wheel, into which the steam is directed by a valve. When it is desired to stop the wheel, said valve closes the passage. The steam rises against the wheel, and impels it with a force governed by the height of the

water column and the amount of steam generated. In the upper part of water chamber, the steam condenses and flows back into the boiler.

728. Improved Road Scraper.

This invention is a machine for grading roads. The forward ends of a mould board and land side are securely attached to a cast point which is made somewhat like a plough. The lower part of the mould board is faced with a steel plate, which projects beneath the lower edge of the said mould board. By suitable construction, by bearing down upon the rear end of a lever, the forward end of the machine will be raised from the ground for convenience in turning. By lowering the free end of another lever, the rear end of the machine will be raised and supported upon a rear caster wheel. By means of a sharp rimmed guide wheel, the machine may be guided as desired.

729. Improved Rotary Engine.

The object of this invention is to produce a rotary engine which overcomes some of the defects of that class of engines by being built very compactly, having no dead centres, and reversing with perfect ease. The invention consists of the arrangement in an outer steam cylinder with abutments, of a rotating drum on a stationary hollow shaft with steam ports, by which the steam is alternately applied to vibrating gates placed at right angles in the two sections of the drum, and exhausted by suitable ports.

730. Improved Coffee Pot.

The pot is composed of three different sections—the upper or water receptacle, the middle one, into which the gas, alcohol, or coal oil lamp is placed, and the lower receptacle for the coffee or other articles which are intended to be boiled. The lower part is detachable, and the coffee, tea, &c., placed therein. The upper receptacle is filled with water, closed tightly, and the lamp then lighted. The generation of the steam forces the boiling water up through a tube to a glass bulb, and then, through a smaller tube and strainer, to the lower part, extracting the strength of the coffee. The lamp is then extinguished, and the liquid slowly drawn up again into the water receptacle. The process is repeated if the coffee is desired to be very strong. The glass bulb or tube indicates, by the passage of the liquid through it, the different stages of the cooking process. The coffee is then drawn off for use.

731. Improved Heater and Feeder for Boilers.

To the feed water pipe, and a certain distance apart, are connected tubes leading from the lower rear portion and from the middle of the under side of the boiler. The water forced along the feed pipe past the junctions with the tubes naturally induces currents from the boiler by the friction of its particles with the particles of the water coming in at the other pipes, which, uniting with the feed water, re-enters the boiler again along with it. To increase this action, a contrivance similar to the head of a steam syphon or injector is arranged in the feed pipe at the point of entry therein of each tube. By this plan it is claimed that the feed water will be heated nearly to the degree of the water in the boiler, which is much greater than it can be heated by the ordinary feed water heaters.

732. Improved Steam and Vapour Generator.

This invention relates to the instantaneous development of steam or vapour from fluid substances by application of the substances to highly heated surfaces in expanders. The essential feature of the invention is a series of hollow spherical balls or expanders, with a feed pipe and jet bulb to each, so arranged that each receives its due measure of feed in such small quantity that the force of the instantaneous expansion is controlled by the balls, and the vapour produced is sent therefrom, along with that from the other balls, to the pipe which conducts it to the engine, in such manner that there is no accumulation anywhere larger than the conducting passage. By this means, it is claimed, the great pressure attainable by the direct contact of the fluid with the red-hot metal can be controlled as it could not be in large chambers affording any considerable accumulation. Another feature of the invention is an arrangement of the expansion balls in the furnace so as to be directly surrounded by the fire, to bring the fluid into the most direct contact with the highest heat of the fire.

733. Improved Pipe Joint.

This invention consists in pipes having corresponding end enlargements, with two annular recesses to form chambers, the former to receive an extension, and the latter to form a close chamber for packing, so that the packing will not be exposed to the water or acid, and thus gradually be forced out of its place into the pipe.

734. Improved Combined Shutter and Window Fastener.

This invention consists in fastening the catches of a shutter and window by the same lever, but so that they may be unfastened separately. The arrangement is such that, when the shutter or door is fastened, all parts, except the inside handle, are concealed from view, and access from without for forcible entry is effectually prevented, and the fastening and unfastening of shutters can be effected without opening the windows. A spring is arranged with the shutters to throw them open when they are unfastened. It may also be used with gates and doors, if required. The spring catch is provided with a metal case made in two parts, which form a lining for the mortise through the sill or frame. The parts of the said casing are contrived so that, when they are placed together preparatory to being put in the mortise, they receive the pivot of the catch in opposite holes formed for it, and are held together to confine the catch by the walls of the mortise. The said lining may be provided with a flange on the inside of the sill, to prevent it from being pulled outward. The invention also consists in utilizing this shutter fastening for locking the window sash by means of a stud catch on it, projecting down from the lower edge, and engaging the spring catch.

735. Improved Cooking Stove.

This invention is an improvement in the class of stoves whose fire boxes are provided with movable or adjustable backs. The improvement relates to the arrangement of two pivoted or hinged plates, one forming, when elevated, the back of the fire box and supporting the other, which thus forms the horizontal inner top plate of the stove.

736. Improved Spring for Chairs, etc.

To the lower part of the seat is attached a centrally slotted metallic plate. Through this passes the screw, by which the chair seat is raised and lowered. The seat slot is elongated to admit of the oscillation of seat. Two rubber blocks are placed one upon each side of the plate, and may be kept from turning by toes, said toes entering notches in them. The toes, when the chair is oscillated, press laterally against the rubber, and thus make the spring more efficient.

737. Improved Fishing Stake.

This invention consists of a fishing stake composed of two parts connected together by a socket and spring catch, in such manner that the upper portion can be readily detached from the lower portion, just above the ground when the season is over, to be preserved, and then be readily attached again at the beginning of another season.

738. Improved Mangle.

The mangle is firmly secured by suitable clamping screws to the table. The standards, of cast-iron, support the mangle rollers. The shaft of the upper or pressure roller turns in a frame which is pivoted to the standards above the clothes roller. The upper roller is made of larger diameter than the lower, both being made of cast-iron. The frame is also made of cast-iron, in forked or U shape, with a central lever, extending toward the person mangling, which is supplied with a handle for pressing the roller down, or with a weight suspended at its end for producing the necessary pressure on the lower roller. The frame is applied to standards eccentrically, so that the pressure of the roller, when brought down to act on the clothes roller, is in proportion as the degree of eccentricity to the length of the lever and the weight applied, which may be increased or decreased according to the power desired to be exerted. By holding with one hand the lever of the pressure roller, and turning the crank with the other as long as desired, the clothes are rapidly mangled. They are then taken off and replaced and run through the roller again, and so on till they have all passed through the mangle.

739. Improved Rock Drill.

This invention consists in fastening drills in a solid chuck, stock, or head, by a couple of half boxes and tapered bolts, the said half boxes having the shank of the drill between them, and entering the socket of the stock. The bolts pass through the stock on opposite sides, and bear against the back of the boxes in grooves, so as to wedge them tight against the shanks of the drill, and hold it in the boxes, and also hold the boxes from working out by the notches in the back.

740. Improved Shaving Conductor for Planing Machines.

The object of this invention is to produce an improved shaving conductor for wood working machinery, by which the shavings are carried off by the force imparted by the rapid revolutions of the cylinders and side cutters, and transmitted to elevators or other receptacles, whether used with or without suckers or blowers. The conductor, covering the machinery, protects the gearing against the accumulation of shavings, leaves every part of the machine fully within view of the workman, and permits readily any repairing of the same at any desired moment. The invention consists, mainly, of a hood-shaped conductor adapted in form to a cylindrical planer and side cutter, combined with an extension casing leading to the opening of the blowers, suckers, or receptacles, and turning in a circular sleeve, so as to be lifted off the machinery. The chip breaker of the side cutter is suitably enlarged and recessed for the passage of the shavings into the conductor, which may also be arranged separately for the side cutter.

741. Improved Curtain Fixture.

This invention has for its object to improve the construction of the shade roller described in a previous number. Upon each end of the roller is slipped a metallic tube, which tubes are made with dies, so as to be exactly of the same size and perfectly true. The tubes are designed to receive the side parts of the shade, and cause it to roll up true, thus obviating the annoyance in hanging and using shades arising from the rollers not being exactly true. In the sides of the tubes are formed small holes, to receive tacks, which at the same time fasten both the shade and tube to the roller. A broad beaded screw is screwed into the ends of the roller, which, in connection with the end of the tube, forms the spool upon which the suspension cord is wound. By this construction the length of the spool upon which the cord is wound may be adjusted as required by simply turning the screw in and out. Upon the outer edge of the end of the tube is formed a flange or bead, projecting outward, and upon the outer edge of the head of the screw is formed a flange or bead, projecting inward. These flanges or beads are designed to bear against the cord when it comes to either end of the shank of the spool in being wound thereon, so that it cannot make more than one coil upon itself, and to cause it to at once begin to pass back along the spool.

742. Improved Riding Attachment for Ploughs.

This invention is an improvement in riding ploughs, and consists in an arrangement of plough beam with a triangular frame, supported on caster wheels, the parts being so connected that the same rods which serve to brace or hold the plough beam in proper position serve also as draft rods.

743. Improved Carriage Spring.

The upper and lower halves of an elliptic spring are of uniform size, and composed of three leaves. Flanged plates are on the outside of these halves, the flanges of which project inward. A knee joint stay is grooved, the ends of which are attached by joint pins to forked bolts passing through the plates and through the halves. The joint in the stay forms the arc of a circle, which places the centre of the joint outside of a straight line drawn from one to the other of the joint pins at the ends of the stay. When the spring is compressed the joint gives, and when the spring reacts, the stay limits the motion and prevents breakage. Springs of angular form at the ends of the elliptic are confined to clevises at their angles, with their ends resting on the plates within the flanges. Springs of oval form are also similarly confined to the clevises, with their other ends separated and extending inward. Pads of rubber are attached to the inside of one of the ends of each of these springs. When the elliptic is compressed, these ends are brought in contact with each other, and the pads prevent noise. These springs may be so arranged that, at ordinary pressures, they will not act, and so that they will not be brought into requisition, except when the pressure is sufficient to jeopardize the safety of the elliptic, but they are designed to act as a safeguard at all times.

744. Improved Vibrating Propeller for Vessels.

This invention is an improvement in the class of propellers formed of paddles or buckets hinged to horizontal shafts or arms, which vibrate on a vertical axis. A hollow vertical crank shaft extends from inside down through the bottom, and is stepped at the bottom of the keel. Below the bottom of the boat this shaft carries two arms extending from opposite sides nearly the width of the bottom of the boat. The buckets are hinged upon these arms to swing freely between short secondary arms, which project laterally in two sets at right angles to each other, so that the said buckets are only swung a quarter of a revolution. Any suitable number of these crank shafts and propellers will be used in a boat, being arranged at intervals throughout her length, and the power may be connected to them in any approved way.

745. Improved Saw Set.

The body of the saw set is made in two parts, the rear parts of which are secured to each other by a screw bolt which holds them together, and by a pin that prevents lateral movement. The lower part is made with a downward projection to enable it to be held by a vice. Two arms, projecting at right angles from the opposite sides of the lower part, and the bases of which project along the sides of said part, are secured to it by a bolt which passes through it and through slots in the bases of the said arms. The parts of the bolt that pass through the slots in the said bases are flattened so as to hold the arms exactly in line with each other. Upon the upper sides of the bases of the arms are formed projections, to enter the spaces between the teeth and stop the saw plate in proper position for the tooth to be operated upon, while the arms support the saw plate in a horizontal position, so that it cannot spring or bend. By loosening the nut of the bolt, the arms may be readily adjusted according to the size of the saw teeth.

746. Improved Grain Conveyer.

The object of this invention is to obviate the necessity of shovelling grain in the holds of vessels, for the purpose of distributing it and properly trimming the vessel. A shell wheel is arranged, composed of a bottom plate and an inclined annular upper plate, separated by vertical partition plates, which latter divide the space between the two plates into a series of compartments which have their outlets at a space between the outer edges of the upper and bottom plates. This wheel is placed below the hatch and given a rapid revolving motion, and the grain, supplied by suitable hoppers and conduits, is thrown from the wheel, through the compartments and space, by centrifugal force against the sides of the vessel and bulk heads. The grain is thus distributed, as fast as the elevator delivers it, it is claimed, without hand labour, and in the most perfect manner. The speed of the machine may be regulated by means of cone pulleys or otherwise, so as to simply clear the wheel and allow the grain to fall nearly vertically for filling the middle of the hold.

747. Improved Liquid Measure.

This invention consists in arranging a measure of suitable size with a vertical central slide gate, which is provided with a horizontal subdivisional shelf, so that, at pleasure, the whole half or other subdivisional measure may be filled.

748. Improvement in Hardening the Surfaces of Iron.

The object of this invention is to furnish a suitable compound for case-hardening iron, or converting the surface into steel: and it consists in lamp black, salt soda, muriate of soda, and black oxide of manganese. The iron is heated in any suitable forge or furnace, and, having been wrought into the shape of the implement or article to be used, the surface thereof is prepared by grinding. The compound is applied by sprinkling or sifting, or by immersing the iron therein. The effect is to carbonize and steelify the surface of the iron.

749. Improved Bolt for Doors and Gates.

The inner plate of the fastening is cast with two keepers to receive the bolt, which has a loop cast upon it to serve as a handle for operating it upon the inner side of the door. The rear keeper is cast with a transverse slot through its middle part, to allow the handle to pass through when slipping the bolt into place. The outer plate is cast with a flange to overlap the edge of the door. A loop or handle, the stem of which passes through a slot in the outer plate, a slot in the door, and a slot in the inner plate, enters a hole in the bolt, where it is secured in place so that the bolt may be moved back and forth from the outer side of the door or gate. Upon the outer plate is cast a loop, which is made exactly like the handle in size and form, and which serves as a guard to prevent the bolt from being pushed back by accidental means.

750. Improved Mitreing Machine.

This invention is an improvement in devices for forming mitre joints, wherein the bar, against which the stuff is fed to the saw, is pivoted to another bar adapted to slide in a groove in the saw table. The sliding bar may be reversed, and is designed for use as a stop when a number of pieces of the same length are to be sawn.

751. Improved Table Knife.

This consists in a simple and effective mode of securing the handles of cutlery to their holding tangs; and it consists in the employment of a bent piece of metal, angular plate, or cap, made of any suitable metal and configuration, applied to the handle next to the bolster, or at its lower end, and provided with an opening for the insertion of the holding tang, which is secured in position by a rivet or pin passed transversely through the cap plate, handle, and tang.

752. Improved Paint Compound.

This invention is especially designed for projecting stone walls and outer surfaces of all kinds, cellar and stable walls, machinery, etc., and is for painting wood, and producing wall and roof papers. The compound is impervious to moisture and air, of great durability, and, though pliant and elastic, of great hardness after having thoroughly dried. It consists, mainly, in silver litharge ground with sesquioxide of manganese, to which balsam of sulphur turpentine is added. Said balsam is produced by dissolving sulphur and linseed oil in turpentine, the dissolution being accelerated by heating. Zinc white is then added to the foregoing, thoroughly ground, and then combined with soluble glass, Venice turpentine, spirits of turpentine, oil varnish, pulverized metallic iron, and Portland cement. The whole compound is then thoroughly mixed and ground together, producing a bluish gray paint, which may be coloured to any desirable tint by adding the colouring pigments in suitable quantity.

753. Improved Toy Putty Blower.

This invention consists of a putty-blowing tube for children, constructed by simply rolling up the sheet into cylindrical form, and overlapping the edges for the joint, without solder or other fastening, with a mouth-piece, whereby the lips are protected from the sharp edges of the metal.

754. Improved Fireplace Lining and Front.

Heretofore it has been a difficult matter to construct an ornamental lining for grates and fireplaces that would stand the continual expansion and contraction to which such linings are exposed from repeated fires without breaking the tiles or blocks of which it was composed, or breaking them loose from the wall to which they were attached. This ornamental lining has usually been fastened with cement, but the tiles or blocks have been set like window panes in metallic frames. These difficulties are designed to be overcome by the present invention, in which tiles of any form or description, or metal blocks of any design, figure, or size, are securely bolted or fastened to a metallic backing made in the form desired for the fireplace or grate, room being allowed for expansion, so that the lining is not damaged by the heat. The same inventor has also devised a novel means for holding an ornamental tile front for fireplaces in its proper position. The tile is confined to a cast metal frame by means of border mouldings. The outer edges of these mouldings are flush with the outer flanges of the frame. The inner edges lap on the tile so as to securely hold it in place, and bolts are cast into the mouldings, which pass through the frame by which the mouldings are held.

755. Improved Car Coupling.

The drawbar has vertical slots at the sides for the admission of a lever. One slot has at its upper end a notched recess toward the open side of the drawbar, which supports the lever when raised to admit the coupling link. The latter is provided with two notches, wedge-like ends, and a higher central part. When the link enters the drawbar, it passes, with its end, below the raised lever till the central bar strikes the same and causes it to drop into the notched part of the link. A pivoted triangular plate presses by its own weight, with its base, on the lever, to prevent the escape of the coupling link, in consequence of the jerks and vibrations of the car. To a lever extension of the plate, and also to the end of the lever, is connected a wire rope which connects with a treadle on the platform of the car, so that the attendant may easily raise the plate, and with it the lever, into the recess, in readiness for coupling.

756. Improved Apparatus for Compressing Cast Metals.

The object of this invention is to provide a portable convenient apparatus for solidifying cast metals in their liquid state by compressed air, which is forced directly on the top of gate in flask after the metal is poured. This invention consists of a portable reservoir for compressed air, with a pump attached, which latter is connected by rubber hose with a cylindrical cap that is fitted and clamped to a cylinder that is fastened to the top of flask. Both cylinders are coupled together by projecting flanges and clamps. The flask cylinder is provided with a clay wash, and, previous to the pouring of the liquid metal, with ring or cap-piece, set on top to prevent the hot metal from coming in contact with the clay wash. The ring is removed as soon as the metal is poured, the cap is then clamped on cylinder and a stop-cock opened, so that the compressed air is let directly on top of metal through the gate of flask, compressing thereby the metal in the moulds.

757. Improved Car Coupling.

The drawhead is rounded off at its front part and provided with a backwardly curved hook, over which the coupling link slides easily, and is then retained without being disconnected by the jerking of the car. The coupling link is pivoted to the drawhead, and at one side of the latter are arranged a series of upwardly inclined holes of different heights. A bell-crank shaped lever with a treadle is pivoted, sidewise of the link, to the link pivot-bolt, projecting with its curved extension hook under the link and lifting the same into horizontal or inclined position when lever is turned. When in inclined position for coupling, it is secured therein by placing a pin into one of the holes before mentioned, selecting the hole required for producing such an inclination of the link as the height of the platform of the car to be coupled renders necessary. The coupling link strikes then, on the approach of the adjoining drawhead, the curved hook of the same, and is thereby gradually raised, allowing the pin to drop out, and passes over the hook, dropping on the drawhead back of the hook and coupling the cars. The uncoupling is quickly performed, as merely the lifting of the link above the drawhead, by pressure on the treadle, is required.

758. Improved Urinal.

This invention consists, mainly, in a vessel of broad oval base and flat shape, with a handle arranged at the top, in such a manner that the centre of gravity falls to the rear of the same. The rear part is covered under suitable inclination, so that the upsetting is prevented, while the forward projecting pointed spout in front of the handle facilitates the use, and furnishes an opening of sufficient size for thoroughly cleaning.

759. Improved Milk Can.

This invention consists in a conical cover for the can, with openings at or near the base, and tubes in connection with them; also, an opening at the top and a tube in connection with it, for ventilating the can and carrying of the animal heat and the odours of the milk. Fresh cool air is carried in at the lower holes by blowing against the cover, and forces the warm air out through the tube at the top, so as to cool the milk efficiently as it is in waiting on the stand at the farmer's gate, or when being conveyed to market. This milk can is intended principally as a carrying can in connection with the cheese and butter factories.

760. Improved Churn Dasher.

The dasher is made in the form of a two-armed bar. Upon the upper side of one arm is formed a rounded hollow, or concave groove, inclining outward and upward, and in the under side of the other arm is formed a similar groove inclining outward and downward. Upon the upper side of one arm and upon the upper side of the other, respectively below and above the other grooves, is formed a recess having a convex bottom and vertical sides. The outer shoulder of the recess is curved and extends from the forward side of the dasher arm to about the centre of the rear side of said arm, where it terminates in a notch. By this construction the dasher, in its movement, throws the milk in currents in different directions, which currents collide with each other and with the sides of the churn, throwing the milk into violent agitation, and bringing the butter in a very short time.

761. Improved Ventilator and Pipe Hole Plate for Tents.

This invention consists of a metal plate having a hole for ventilation, or for the projection of a stove pipe fastened in a large opening in the tent cloth and provided with a valve for closing the ventilator or pipe hole. The plate supports the valve and the stove pipe protects the cloth from the heat of the pipe.

762. Improved Carriage Top Joint.

The object of this invention is to provide, for the purpose of raising and lowering the tops of carriages of all kinds, an improved joint or prop, by which the braces are effectually extended and rigidly supported when the top is thrown up, and neatly and compactly arranged when folded down. It consists of a combined joint for the braces of a carriage top, so that the same folds easily into parallel position, together with an abutting extension of the supporting brace, which locks a projecting rib into a corresponding recess of the extended brace, for keeping it rigidly in position when the top is opened.

763. Improved Machine for Building Earthworks.

This invention consists of a strong frame, mounted on castors or wheels for moving along the ground readily, and having an elevated platform hinged at one side, and held down at the other side upon powerful springs, on to which the earth is scraped up an ascending way, or otherwise delivered upon it. The earth is finally discharged in the direction of the place where it is to be spread by tripping the platform and allowing the springs to throw it up with sufficient force to project the earth from it. A windlass is employed for forcing the platform back again for reloading, with ratchets and pawls for holding it. This machine is more particularly designed for levee building and, it is believed, will be found very serviceable in building up banks of considerable height, by saving much of the labour of the animals in moving themselves and the scrapers up and down the banks.

764. Improved Latch for Gates.

This invention has for its object to improve the construction of the latch for which latters patent No. 128,075 were granted to the same inventor June 18, 1872, so as to make it more reliable in use and less expensive in manufacture. The catch moves up and down through a slot in the bottom edge of the case, and has hooks formed upon the outer and inner ends of its upper side. The inner arm of a lever passes through a slot in the top edge of the case and enters the cavity of the catch; and its lower end is so formed that, when moved inward, outward, or upward, it may raise the catch and unfasten the gate or door. The upper arm of the lever projects upward, to serve as a thumb piece for operating. Upon the lever is a plate, so formed as to wholly cover said slot or opening, and thus prevent the entrance of rain and snow into the case. A partition is formed in the inner part of the case, and its upper part is curved to serve as a stop to the catch when thrown upward by the slamming shut of the gate, to cause the catch to drop, before the gate in its rebound can carry the catch bar out past the catch.

765. Improved Hub Boring Machine.

The frame of this hub boring machine consists of a larger base part and the vertical standard supported thereon. The larger part is laterally connected by pieces which support the wheel to be bored in horizontal position, forming a platform for the same, to which it may be rigidly fastened. A lower lateral piece carries centrally a vertical, to which are pivoted the toggle levers, which have jaws at their upper ends, which take hold of the hub at diametrically opposite sides, and centre it accurately below the boring mandrel. Jaws are adjusted to the hub by a link connecting the toggle levers and screw, which is placed vertically below the axis of the mandrel, securing thereby the exact central position and bore of the hub. The mandrel is set, in the usual manner, in vertical position on the standard, and driven by hand or other power.

766. Improved Shoe Last.

This invention consists of detachable plugs of wood and a fastening device composed of a screw-threaded bush and roller screw in the bottom of the last, for driving the tacks into and temporarily fastening them on the soles. The object of this is to remove the plugs and fit in new ones from time to time as they wear out, and thus always have solid substance for the tacks. This part is applicable to the soles having a metal plate on the bottom for riveting or clinching the tacks by which the insole is fastened to the upper in the process of making machine-sewn shoes.

767. Improved Sleeping Car.

The seats of the lower berths are constructed of three pivoted cushions, the main cushion forming the seat, and the others the back. The seat can be swung out to make the middle part of the berth. A lug-shaped extension limits its motion, and it is suitably supported when drawn out for the berth. The back cushion is folded down into horizontal position into the place made vacant by seat. Either back cushion may be slightly elevated into an inclined position for head rest, and secured. The seat frame dividing each section extends slightly above the top cushion when in position as back cushion, and allows thereby a full view of the car and a free passage of air through the same. When the top cushion is locked in its upward position it serves as support for the upper berth, which is arranged immediately under the top of the car, supported in front by horizontal projections, and in the rear by bolts, which lock into nosings provided at the upper end of guide grooves. When it is desired to lower the upper berth, rear bolts are withdrawn, so that the rear side of berth slides down in grooves while the front part swings in pendent arms. The berth assumes thereby an inclined position. Front bolts are then withdrawn from pendent arms till the birth, swinging on pivots, assumes a horizontal position, resting on the up turned top cushions. The same operation is reversed when placing the berth back in its old position, the front and rear bolts locking by mere pressure by the action of their spiral springs.

768. Improved Gate Fastener.

This invention relates to the class of gate fastenings so contrived that the gate closes under the catches, and is then lifted up into them and held by a suitable arrangement of levers. A weighted eccentric lever is employed, which effectually secures the gate while it remains down; and only releases it on being lifted up.

769. Improved Ice Creeper.

Upon the upper side of a narrow plate, which reaches across the sole of the boot and along its side edges, are formed grooves to receive the side edges of two plates, the inner parts of which are halved, so as to overlap each other without producing any extra thickness. The movements of the last mentioned plates, as they are slipped out and in, are limited by pins which project through short longitudinal slots. The outer ends of the plates are bent upward at right angles, and have spikes attached to them to enter the edges of the boot soles. A set screw passes up through the narrow sole plate, so that its forward end may press against the plates and hold them against the flanges that form the grooves in which the edges of the said plates work. To the under side of the sole plate are attached short spikes to take hold of the ice, and thus prevent the wearer from slipping.